# ECONOMIC BOTANY

DEVOTED TO APPLIED BOTANY AND PLANT UTILIZATION




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## ECONOMIC BOTANY

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# ECONOMIC BOTANY

**Devoted to Applied Botany and Plant Utilization**

*Founded by Edmund H. Fulling*

VOL. 14 JULY-SEPTEMBER, 1960 No. 3

## News of

# THE SOCIETY FOR ECONOMIC BOTANY

### ANNUAL MEETING ANNOUNCEMENT

The following schedule for the second annual meeting has been proposed: The dates for the meeting are Saturday and Sunday, May 13 and 14, 1961, at the Massachusetts Institute of Technology, Cambridge, Mass. All meetings, luncheons, and dinners will be held in the M.I.T. Faculty Club on Memorial Drive, Cambridge. The pattern for the meetings will be essentially the same as for the first annual meetings, as follows:

MAY 13

| | |
|---|---|
| 9:00–12:00 | 10–15 minute papers on general topics relating to economic botany. Chairman: L. O. Williams. |
| 12:30 | Luncheon (M.I.T. Faculty Club). Speaker introduced by A. F. Hill. |
| 2:00– 5:00 | Continuation of general papers. Chairman: W. H. Hodge. |
| 5:30– 6:30 | Cocktails, M.I.T. Faculty Club. |
| 7:00– 8:30 | Dinner: Speaker—Dr. Ernest Guenther, President of the Society. Film: "Essential Oils in South America." |
| 9:00–10:00 | Open House: Laboratory of Economic Botany, Botanical Museum of Harvard University. Exhibits and samples of economic plant products will be offered. |

MAY 14

| | |
|---|---|
| 9:00–12:30 | Symposium: Integrated Research in Economic Plants. II. Nutrition for an Expanding World Population. Half-hour papers followed by ten minutes of questions. Specialists are being invited to participate from the following fields: botany, anthropology, nutritional studies, biochemistry, agronomy. Speakers will be announced shortly. |

The most convenient hotel for M.I.T. Faculty Club is The Palmer House, Boston. Single rooms run from $9.50 to $11.50 per day; double bed, $14.50 to $16.50; twin beds, $16.50 to $18.50. Requests for reservations should be made directly to the Palmer House.

Contributed papers and any other information concerning the program should be addressed to:

Dr. Richard Evans Schultes, Program Chairman,
The Society for Economic Botany
Harvard Botanical Museum
Cambridge 38, Massachusetts

You may register for the meeting in advance by sending $1.00 to Dr. Schultes or upon arrival at places to beannounced.

The Council will meet in The Palmer House on Friday evening, May 12, at 8 p.m.

## Other Items of Interest

### NEW PERIODICAL

CROP SCIENCE is the name of the new research journal which will appear in February 1961 as the official publication of theCrop Science Society of America, an affiliate of the American Society of Agronomy.

CROP SCIENCE will be a companion publication to AGRONOMY JOURNAL, the official organ of the ASA. It will alternate in publication dates with the JOURNAL and will carry the articles (formerly publishable in the JOURNAL) of direct interest to workers in the above-mentioned areas of research. AGRONOMY JOURNAL will continue to carry the articles of wider agronomic scope—of interest to both crop and soil scientists, seed and weed technologists, plant pathologists, agricultural meteorologists, and others.

Publication of research reports in CROP SCIENCE will be open to members of the Crop Science Society—with joint membership in the American Society of Agronomy. Detailed information on publication in or subscription to CROP SCIENCE or AGRONOMY JOURNAL or both may be obtained from the American Society of Agronomy, 2702 Monroe Street, Madison 5, Wisconsin.

### THE FAO FREEDOM-FROM-HUNGER CAMPAIGN

The statistics of want are fragmentary and uncertain. Reliable and fairly comprehensive food consumption surveys have only been carried out in a few countries and those few the countries where living levels are high. But it does seem fairly clear that substantially more than one half of the world's population is either underfed or, because it is not getting the correct variety of foods, is malnourished.

This situation is accompanied by illiteracy, ignorance, high disease rates, low life expectancy, poor housing, low productivity, lack of security.

This is not a new situation for right though history most men have lacked food and their search for it has been the basis for exploration of the globe, for settlement of new lands and even for war.

What is new is that hunger is not necessary any longer, that in a shrinking world more and more people are learning this and that they are determined that they, too, will be well-fed.

What is new, too, is the high rate of population growth in the modern world. Man's numbers have doubled in the past sixty years and will probably double again—to six billion—in fewer than 40 years from now.

This rise in world population is not the cause of world food shortages even though it adds an extra edge of urgency to the problem. The problem is not a pressure of demand against resources, of too many people to be fed and too little land to feed them—some of the most densly-populated parts of the world are also among the best fed—like Belgium and the Netherlands. Many backward farmers gaining a woefully poor livelihood from a couple of acres of land would live very little better on 20 acres.

For the most part the backward farmer does not lack land so much as the knowledge and skill and resources to make the most of the land he has.

In the highly developed country very little farmland suffices to feed each person and in recent years we have seen crop areas reduced while food production continued to mount.

In very simple terms, the answer to the world food problem is to bring to the underdeveloped countries the techniques which have brought material prosperity and freedom from want to the highly developed countries.

The achievements of agricultural research in the world's few well-fed countries suggests that, far from moving towards a physical limit set on production by the availability of land resources, the limits on production are receding and it is becoming less possible to say where these limits lie.

This answer to the world's food problem has been obvious for several decades—it is only within the last 15 years that any serious attempt has been made to apply it on a world scale.

In October 1945 the Food and Agriculture Organization was set up to assist countries to pool their knowledge, energies and resources in a world campaign against hunger.

In the years since then, FAO has worked on a number of levels to help improve the situation—it has, for instance, sent more than 2,500 experts into more than 60 countries to help them deal with their problems in the fields of agricultural economics and technology, fisheries, forestry and nutrition.

During this same period bilateral aid programs have also reached a scale never approached before and national action has also increased.

All this effort has not been sufficient to turn the tide. In the world as a whole, food production per head of population has hardly risen above levels achieved before World War II and since the greatest advances have been achieved in the most prosperous countries, there are considerable areas of the world where food supplies per person are probably still below the deplorably low levels of 30 years ago.

Not only have all efforts failed so far to bring any appreciable easing of the position but no other programs which are at present under way appear likely to provide sufficient impetus to world development to change the situation appreciably. The outlook is for a world in which needs will continue to rise and in which predominant want will be relieved only spasmodically by scattered aid programs.

It was to meet this growing problem that in the summer of 1958 FAO Director-General B. R. Sen proposed the Freedom-from-Hunger Campaign. His proposals were formally approved by the 77-nation FAO Conference in November 1959 and have been promised the support of other United Nations agencies, of governments, of international non-governmental organizations and of industrial groups and association.

The Campaign was officially launched in 1 July, of this year.

## WHAT IS THE FREEDOM FROM HUNGER CAMPAIGN?

The Freedom-from-Hunger Campaign is not intended to replace any development programs at present being carried on. It is intended to match these programs with new projects and to create a more favorable climate of opinion in which all programs will proceed more swiftly. It is intended to lead to the discovery of further knowledge of the world food problem and of techniques of solving it.

It is intended to enlighten the people of the underfed countries about the possibilities for improving their position so that they will work with greater optimism and determination. It is intended to encourage people of the prosperous countries to take a greater part in the drive on hunger and to provide the means for them to do so.

It is not a charity program under which a loaf of bread will be given to this hungry man, a glass of milk to that malnourished child. Such aid is of value in times of crisis but it has nothing to do with a long-term solution of the world food problem which lies in helping the underfed countries to produce ample food for themselves.

It is not expected, nor even considered possible, that the world food problem will be solved by the time of the formal conclusion of the Freedom-from-Hunger Campaign, at the end of 1965.

What is hoped is that by the conclusion of the Campaign the scale and variety of the problem will be better understood, that a unanimity of world determination to solve it will have been created and that new programs of development which will have been started, and will be starting, will inevitably move through to a solution of the problem.

## WHAT WILL BE DONE?

An overall plan has been drawn up for the Freedom-from-Hunger Campaign and a number of detailed activities have been planned to be carried on within the framework of the Campaign—for instance a big drive will be made in 1961 to persuade farmers everywhere to use better seeds which usually cost more but yield larger crops.

The Campaign will operate on several levels:

*Informational and educational programs* will spread information about the food problem and about the possibilities for solving it in order to enlist greater public support for the Campaign. Studies will be made of various aspects of the problem such as more detailed examinations of nutritional levels of various population groups in underfed areas, of the possibilities for increasing food production, of the relation between population and food supplies and so on.

Through *research programs* new techniques will be developed for increasing production.

At the heart of the Campaign will lie *national action programs*. Although no solution of the food problem has yet been brought within reach, the efforts which have been made so far have demonstrated time and time again the value of the action program which shows the farmer how he can improve his production and provides the supplies and help to enable him to do it. Thousands of projects under bilateral aid programs and under UN sponsorship have, in various areas, conquered livestock diseases, increased crop yields, made new foods available, multiplied fisheries catches and brought security and modest comfort to impoverished farmers and fishermen.

The aim of the Freedom-from-Hunger Campaign will be to increase the scale of these action programs and to multiply their number many times. It is in this field of the Campaign that the greatest resources, the greatest human goodwill and the greatest human effort will be needed. It will need great expenditure by governments and organizations of prosperous countries and it will require great efforts by assisted countries to make the best use of the aid they are given and to supplement it from their own resources. It will require millions of farmers in underdeveloped countries to abandon farming methods which their fathers and grandfathers have practised and it will require understanding and generosity from people who can spare money and time to make the Campaign successful.

## WHAT THE INDIVIDUAL CAN DO

A national Freedom-from-Hunger Campaign Committee will be set up in your country. Citizen's action groups and similar bodies can help to organize regional meetings.

If you are a member of an organization with international affiliations it has probably already participated at planning conferences at FAO Headquarters in Rome and will be announcing programs in which you can participate.

Towns and local communities can support projects under the Campaign. They could:

Provide seed or fertilizer for a crop improvement project.

Equip an agricultural research laboratory.

Finance a fellowship to give an agricultural technician a period of overseas training.

Adopt a development project in an underdeveloped country.

Contribute to FAO's Campaign Fund—contributions will be spent on action projects and used in part to defray the expenses which FAO is meeting in organizing the Campaign.

If you have no other way of keeping in touch with the development of the program write to one of FAO's offices listed below and we will keep you informed of developments.

THE FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS

North American Regional Office
1325 C Street, S.W.
Washington 25, D.C.

Information Liaison Office
Room 372, United Nations
New York 17, N.Y.

# Vigor in an Interspecific Hybrid of Sansevieria[1]

*$F_1$ hybrids of S. trifasciata x S. deserti were distinctly superior to either parent species in terms of total green yield, percent fiber leaves, fiber leaf yield and fiber yield in tests conducted on Everglades peat and Immokalee fine sand in south Florida. Apparently the hybrid vigor in the $F_1$'s can be accounted for by a combination of favorable growth factors from the 2 diverse parent species. Generally the fiber quality of the hybrids was equal to or better than the parents.*

J. B. PATE, J. F. JOYNER and C. C. SEALE[2]

The genus *Sansevieria* Thunb. is highly variable and contains over 60 species that have been described botanically (2, 5). Growth habit varies from the flat leaf, non-stem, dense rhizome species to the round leaf, branching stem, non-rhizome species with many gradations between these two extremes. Most species are indigenous to Africa and occur over a wide range of climatic and soil conditions (2). Some species have become distributed throughout other parts of the tropics and subtropics and in many of these areas now are found growing in a semi-wild state (2, 3). Various species of *Sansevieria* are widely used as ornamentals in potted and door-yard plantings (9).

The fiber of certain species of *Sansevieria* has long been used by native peoples in tropical and sub-tropical areas for making crude types of ropes and twines (2, 4, 5). More recently the value of this fiber has been recognized for use in high grade marine cordage (3). The principal supply of marine cordage fiber in the United States is from abaca (manila hemp) which is imported mainly from the Philippines. During World War II the severe shortage of abaca fiber made apparent the need for suitable substitutes that could be grown in tropical and subtropical areas in this hemisphere. At that time certain species of *Sansevieria* seemed to offer the best possibilities as a substitute source of marine cordage fiber. These conditions prompted the U. S. Department of Agriculture and the University of Florida Agricultural Experiment Station to initiate a cooperative research program in 1943 to investigate the growing of *Sansevieria* as a cordage fiber crop in south Florida.

Early varietal work was concerned mainly with the observation and evaluation of *Sansevieria* species found growing in a semi-wild state in Florida, and also with species introduced through the Plant Introduction Section of the U. S. Department of Agriculture. These early experiments showed that *S. trifasciata* Prain was the most promising species available at that time for experimental fiber production in south Florida (4). However, its slow rate of growth, low percentage fiber, disease susceptibility, and insufficient cold tolerance were recognized as factors which might limits its large scale

[1]Florida Agricultural Experiment Station Journal Series, No. 886. The research work on which this report is based was conducted cooperatively by the Crops Research Division and the Agricultural Engineering Research Division, A.R.S., U. S. Department of Agriculture and the University of Florida Agricultural Experiment Station.

[2]Pate: Research agronomist, Crops Research Division, A.R.S., U.S.D.A., formerly at Belle Glade, Florida, now at U.S. Cotton Field Station, Knoxville, Tennessee; Joyner: Research agronomist, Crops Research Division, A.R.S., U.S.D.A., and assistant agronomist, Everglades Experiment Station; Seale: Associate agronomist, Everglades Experiment Station, Belle Glade, Florida.

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commercial use except in an emergency. A breeding program for the development of more desirable types was initiated in 1951. Since that time numerous interspecific crosses have been made among the 21 species available in the Florida collection, and promising hybrids between several of these species have been obtained (6). This paper is concerned with comparisons of *S. trifasciata*, *S. deserti* N. E. Br., and 6 $F_1$ hybrids of these 2 species on 2 soil types in south Florida.

## Materials and Methods

Experiments were conducted on Immokalee fine sand near Lake Worth and Everglades peat near Belle Glade. Leaf cuttings of the 6 hybrids and 2 parents were planted at 6 in. intervals in rows 16 in. apart in 4 randomized blocks in June 1955 at Lake Worth and in 5 randomized blocks in April 1956 at Belle Glade in plots consisting of 8 rows 12 feet long. The experiment on the sandy soil was planted at an earlier date owing to the slower growth rate of sansevieria on that soil type. Soil analyses and standard fertilizer practices were used as guides in maintaining adequate levels of fertility in both experiments.

Counts of number of plants developing from each cutting were made 6 months after planting on 2 center rows of each plot in both experiments. Harvests were made in October 1957, 28 and 18 months after planting at Lake Worth and Belle Glade, respectively. In order to minimize border effects only center areas of plots, 53.6 sq. ft. at Lake Worth and 42.7 sq. ft. at Belle Glade, were harvested for yield. In *Sansevieria*, leaves 20 in. or longer are considered fiber leaves since this length can be mechanically decorticated. Plot green yields were separated into fiber leaves and short leaves. A 10-lb. sample of fiber leaves was taken from each plot and the fiber was extracted on a hand-fed raspador type decorticator.

Leaf lengths were measured on samples of fiber leaves taken for decortication. Total green yields per acre were calculated from harvested plot weights. Percentage of fiber leaves and fiber leaf yields per acre were calculated from the yield of leaves 20 in. or more in length. The fiber obtained by decortication from the 10-lb. plot sample was dried in a forced air oven at 200° F. and conditioned for 48 hours at 70° F. and 65% relative humidity. Percent fiber on a green weight basis and acre fiber yields were calculated from the dry fiber weights.

Fiber quality factors measured were tensile strength, knot strength, abrasion resistance and flexual endurance; for brevity, these are referred to as strength, shear, wear and flex, respectively. Basic methods for making these measurements have been described by Schiefer (8) and Berkley et al (1).

The fiber from each plot was subsampled for quality determinations. Two bundles per plot were taken for strength, and five ½-inch breaks were made for each bundle. Five bundles were taken from each plot for shear, and two measurements were made for each bundle. Three measurements were made from each plot for both wear and flex. All fiber quality tests were made in the Fiber Laboratory at the Everglades Experiment Station under constant conditions of 70° F. and 65% relative humidity.

## Results and Discussion

The performance data for the 2 parent species and 6 $F_1$ hybrids are given in Table 1. Separate analyses for the 2 experiments were made, since it was not possible to combine the data from the 2 locations owing to different dates of planting.

Table I shows that *S. trifasciata* produced more plants per leaf cutting than *S. deserti*. This agrees with previous studies which have shown that *S. trifasciata* is easily propagated by leaf cut-

TABLE I
AVERAGE PERFORMANCE OF PARENT SPECIES AND INTERSPECIES HYBRIDS OF SANSEVIERIA ON TWO SOIL TYPES IN SOUTH FLORIDA

| Species or hybrid[2] | No. Plants per cutting | Leaf length, inches | Percent fiber leaves | Percent fiber[1] | Yield, 1000 lbs./acre Total green | Fiber leaf | Dry fiber |
|---|---|---|---|---|---|---|---|
| | | | Everglades Peat | | | | |
| S. trifasciata | 1.34 | 30 | 30.5 | 1.38 | 123.9 | 40.0 | .537 |
| S. deserti | .40 | 26 | 43.8 | 1.14 | 32.3 | 14.9 | .166 |
| H51-10 | 1.75 | 51 | 87.7 | 0.99 | 335.1 | 294.7 | 2.923 |
| H51-11 | .93 | 46 | 78.3 | 1.23 | 218.1 | 169.9 | 2.092 |
| H51-12 | 1.23 | 45 | 85.2 | 1.20 | 298.1 | 254.2 | 3.027 |
| H51-13 | 1.27 | 56 | 90.1 | 1.35 | 277.3 | 249.7 | 3.386 |
| H51-14 | 1.43 | 56 | 90.6 | 1.04 | 261.8 | 237.0 | 2.459 |
| H51-15 | 1.33 | 48 | 87.6 | 1.23 | 303.8 | 267.5 | 3.267 |
| L.S.D. 5% | | 3 | 10.2 | .08 | 37.2 | 38.1 | .505 |
| L.S.D. 1% | | 4 | 13.7 | .11 | 50.2 | 51.4 | .682 |
| | | | Immokalee Fine Sand | | | | |
| S. trifasciata | 1.32 | 23 | 28.4 | 1.27 | 52.1 | 15.3 | .198 |
| S. deserti | .44 | 24 | 43.7 | 1.53 | 27.6 | 13.3 | .204 |
| H51-10 | 2.38 | 36 | 79.5 | 1.19 | 118.6 | 94.1 | 1.115 |
| H51-11 | 1.23 | 40 | 83.0 | 1.74 | 105.8 | 88.2 | 1.579 |
| H51-12 | 1.56 | 34 | 81.2 | 1.54 | 97.8 | 80.0 | 1.219 |
| H51-13 | 1.58 | 48 | 80.7 | 1.55 | 100.7 | 81.5 | 1.251 |
| H51-14 | 1.66 | 41 | 84.2 | 1.34 | 104.3 | 87.4 | 1.178 |
| H51-15 | 1.33 | 39 | 83.2 | 1.40 | 98.6 | 82.0 | 1.150 |
| L.S.D. 5% | | 3 | 20.6 | .23 | 34.0 | 30.2 | .549 |
| L.S.D. 1% | | 4 | 28.0 | .31 | 46.2 | 41.1 | .739 |

[1]Green weight basis
[2]Letter H designates hybrid

tings (4). There was considerable variation among the $F_1$'s in average number of plants per cutting, but all were better than *S. deserti* and most were equal to or better than *S. trifasciata*. At both locations H51-11 produced the fewest and H51-10 the greatest number of plants per cutting.

In both experiments differences among hybrids and parents in leaf length, total green yield, percent fiber leaves, fiber leaf yield, percent fiber and fiber yield were highly significant. For each of these characteristics, except for percent fiber, the most significant differences were between hybrids and parents, although considerable variation also was noted among the 6 hybrids. The outstanding vigor and superiority of the hybrids can readily be seen in Table 1. Total green yields of most of the hybrids were more than double the better parent. The superiority of the hybrids is even more striking in terms of fiber yield, since a much larger percentage of leaves of the hybrids were of fiber length. The vigor of the hybrids is further illustrated in Figure 1, which shows the parent species and the hybrid, H51-13, immediately prior to harvest in the experiment on Everglades peat.

The hybrid vigor observed in these interspecific $F_1$'s apparently is due to a combination of favorable growth factors from 2 diverse parent species. In the process of evolution *Sansevieria* has been subjected to widely varying environments on the continent of Africa, and many species have been produced as a result of natural selection. The 2 parental species are native to and adapted to entirely different areas of Africa, *S. trifasciata* to the tropical rain forests and *S. deserti* to the desert regions (2). Thus these 2 species probably differ by a large number of favorable growth factors, many of which are combined when $F_1$ hybrids are produced. These combinations of favorable factors from both parents apparently ac-

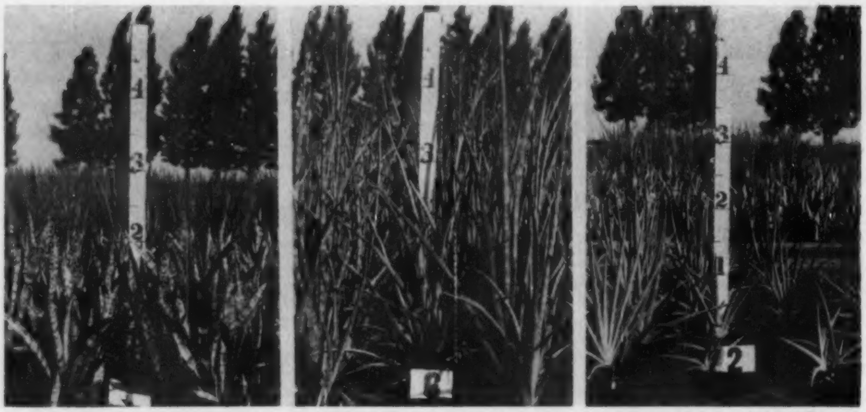


Fig. 1. From left to right, *S. trifasciata*, H51-13 (*S. trifasciata* × *S. deserti*) and *S. deserti* at time of harvest in experiment on Everglades Peat.

count for the extreme vigor of the hybrids. Since the $F_1$'s are perennial and can be easily propagated by leaf cuttings, the maintenance of the vigor is not a problem.

*Sansevieria* is a slow growing perennial, and even the fastest growing species such as *S. trifasciata* require 3-4 years to produce good fiber yields. No natural species of sansevieria can be grown successfully on the peat soils on account of recurring frosts each winter, and consequently the warmer sandy soils of the southeast coast of Florida have been considered the only areas suitable for the growth of sansevieria for fiber. The rapid growth and high yields of the *S. trifasciata* × *S. deserti* hybrids on the peat soil necessitate a reevaluation of soils on which these hybrid *Sansevierias* can be grown. A distinct advantage in growing *Sansevieria* on the peat soil would be a reduction in the cost of fertilizer.

Recovery or regrowth following harvest is an important consideration in *Sansevieria* breeding. *S. trifasciata* produces a dense mat of rhizomes, and regrowth is good. Observations indicate that after the first cutting successive harvests at about 3 year intervals could be realized from plantings of this species on the sand. On the other hand, *S. deserti* produces few rhizomes, and regrowth is so poor that successive harvests are not possible. The vigor and rapid growth of the $F_1$'s of these 2 species, especially in the peat experiment, suggested the possibility of annual harvests following the 1st cutting. Observations made 1 year after the 1st cutting indicate that regrowth of the $F_1$'s has been only fair on the sand and very poor on the peat. The severe winter of 1957-58 in Florida may have had an adverse effect on regrowth, especially in the peat experiment. However, *S. trifasciata* is regrowing well in both experiments.

The fiber quality data are summarized in Table 2. Differences were either highly significant or significant for all fiber quality factors measured except for flex in the experiment on the sand. The quality of fiber of *S. deserti* appeared better than that of *S. trifasciata* for all factors except wear. On both soil types the hybrids as a group were superior to their parents in strength and shear. In wear none of the hybrids equaled either parent on the peat soil, while some of the hybrids were better than either parent in the sand experiment. Flex was quite

variable, but the hybrids seemed to be better than *S. trifasciata* and poorer than *S. deserti.* These fiber quality data indicate that some of the hybrids are about equal to or better than the parents in terms of over-all fiber quality. The quality of fiber produced on the sand was better than that on the peat. Differences in fiber quality due to soil type have been shown to exist in other long vegetable fibers (7).

Although the $F_1$ hybrids look promising, it should be mentioned that $F_2$ and backcross populations of *S. trifasciata* x *S. deserti* show a very great range of segregates, particularly with respect to leaf and plant type. Furthermore, $F_1$ triploid hybrids produced at a later date using 4n *S. trifasciata* and 2n *S. deserti* are extremely vigorous, due perhaps to polyploid as well as hybrid vigor. Selection within these populations may reveal types more desirable than the $F_1$ hybrids, particularly with regard to percent fiber and regrowth following harvest.

TABLE II

MEAN TENSILE STRENGTH, SHEAR, WEAR, AND FLEX OF *Sansevieria* SPECIES AND INTERSPECIES HYBRIDS GROWN ON TWO SOIL TYPES IN SOUTH FLORIDA

| Species or hybrid | 1000 lbs. per sq. in Strength | Shear | Cycles to failure Wear | Flex |
|---|---|---|---|---|
| | Everglades | Peat | | |
| S. trifasciata | 59.2 | 14.8 | 447 | 2383 |
| S. deserti | 60.6 | 18.8 | 388 | 6961 |
| H51-10 | 72.7 | 18.6 | 343 | 6237 |
| H51-11 | 70.0 | 18.4 | 318 | 4891 |
| H51-12 | 70.5 | 18.2 | 214 | 2855 |
| H51-13 | 66.9 | 16.0 | 246 | 4112 |
| H51-14 | 79.3 | 18.1 | 275 | 3848 |
| H51-15 | 66.2 | 17.5 | 273 | 5662 |
| L.S.D. 5% | 6.0 | 1.9 | 129 | 1888 |
| L.S.D. 1% | 8.2 | 2.6 | NS | 2547 |
| | Immokalee | Fine Sand | | |
| S. trifasciata | 69.1 | 15.6 | 302 | 5773 |
| S. deserti | 73.8 | 17.7 | 294 | 7981 |
| H51-10 | 76.9 | 18.5 | 279 | 4843 |
| H51-11 | 78.9 | 17.8 | 335 | 4579 |
| H51-12 | 81.1 | 18.0 | 529 | 5320 |
| H51-13 | 81.2 | 14.9 | 370 | 5412 |
| H51-14 | 86.3 | 19.2 | 354 | 6527 |
| H51-15 | 80.8 | 17.7 | 447 | 6707 |
| L.S.D. 5% | 6.8 | 2.4 | 135 | NS |
| L.S.D. 1% | 9.3 | NS | NS | ..... |


## Summary

The growth, yield and fiber quality of *S. trifasciata, S. deserti* and 6 $F_1$ hybrids obtained from crossing these 2 species were studied on Everglades peat and Immokalee fine sand in south Florida.

The $F_1$'s exhibited considerable hybrid vigor and were distinctly superior to either parent in total green yields, percent fiber leaves, fiber leaf yields, and fiber yields. An explanation for the vigor of the $F_1$'s is given. Yields were much greater on the peat than on the sandy soil.

Some of the hybrids were about equal to or better than the parents in fiber quality. Fiber produced on the sand was of better quality than that produced on the peat.


## Literature Cited


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# Historical Review of Ptelea trifoliata in Botanical and Medical Literature[1]

***Soon after discovery of Ptelea trifoliata in colonial America, this attractive aromatic shrub became popular in Old World botanical gardens. First medical indications as anthelmintic and vulnerary, by Schoepf in 1787, were extended in nineteenth-century homoeopathic literature to include alleged usefulness as a febrifuge, tonic, and in treatment of numerous chronic conditions. Presence of berberine, or other substances reported by early workers, has not been confirmed.***

VIRGINIA LONG BAILEY[2]

## Introduction

In the course of investigations leading to a taxonomic revision of *Ptelea*,[3] a North American genus of the Rutaceae, a number of historical facts appeared which may be of interest to gardeners and those concerned with early medical uses. *Ptelea trifoliata* L. (hop-tree, wafer ash) is an attractive trifoliate shrub or small tree with aromatic glandular foliage, small-cymose inflorescences of fragrant greenish-white flowers, and conspicuous clusters of wafer-like samaras (Fig. 1). The extensive roots are strong-smelling and bitter, with pale yellowish, thick, brittle bark, easily stripped from the branches (Fig. 2). The attractive foliage and the aromatic and bitter properties of the leaves and roots are such that it would have been very unlikely for this plant to have escaped the attention of observing persons as of potential value, whether as an ornamental or for medicinal or other uses.

## *Ptelea* in Botanical Gardens

Although strictly a North American genus, *Ptelea* first became known in literature of the Old World as a result of garden introductions from colonial America (24). Specimens and seed were sent from Virginia and North Carolina by early American explorers and colonists for the gardens of friends or patrons in England and Holland. It was from descriptions or figures of some of the plants which had been introduced into these Old World botanical gardens that Linnaeus obtained the citations which validate his species, *Ptelea trifoliata* L. (20).

Following the recognition of *Ptelea* as a garden plant of high repute in England and on the content of Europe, as well as in America, it became one of the valuable exchange items between gardeners of the old and new worlds. Thomas Jefferson, while serving in Paris as minister plenipotentiary to France, wrote to his friend, John Bartram, Jr., of Philadelphia, requesting seed of *Ptelea,* along with other native American plants and seeds, to be sent from America for friends in Paris (3). Other notes indicate that while he was in London on business, he purchased some seed, including *Ptelea,* from James Lee and Company, "to be sent to Tours, probably for a friend" (3).

In view of the continuing popularity of *Ptelea trifoliata* as a garden shrub for nearly two centuries, from early eighteenth to late nineteenth century, and the accompanying inevitable practice of selection of the specimens best suited for a particular purpose, it is not surprising that a number of horticultural varieties

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[2]Dept. of Biological Sciences, Detroit Inst. of Technology.

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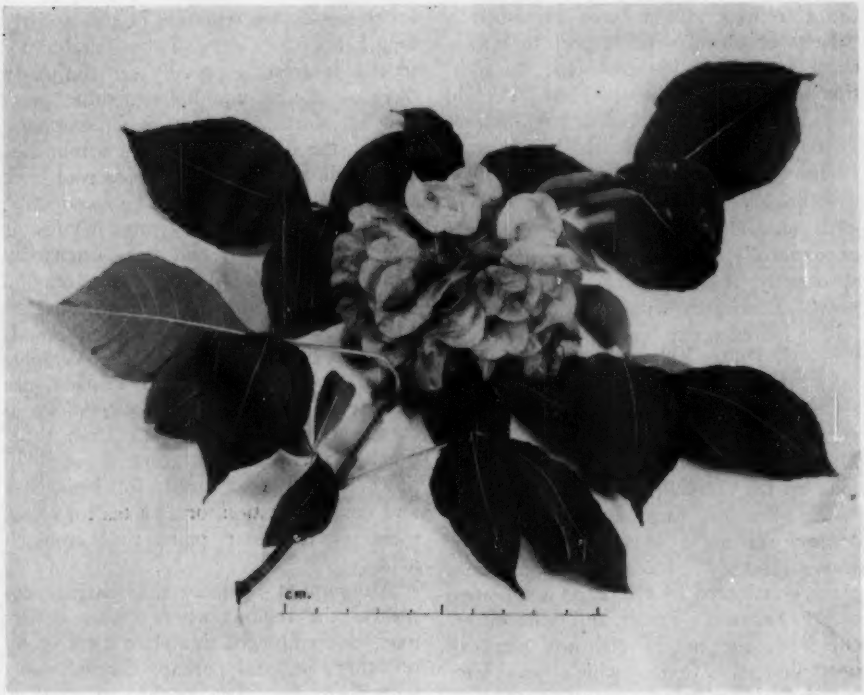


Fig. 1. *Ptelea trifoliata* L. Fruiting branch. Point Pelee National Park, Ontario, Canada, *Bailey 5321*.

have arisen (32). Forms with variegated and blotched leaves have appeared at different times, giving rise to such names as *Ptelea trifoliata foliis variegatus* Hort. (28) and *Ptelea trifoliata* var. *aurea* (6), the latter with foliage golden-yellow ("goldgelben") (8). A report from the culture department of the Arnold Arboretum in 1890 is of interest: "*Ptelia* [*Ptelea*] *trifoliata* var. *aurea* (golden elder) came out a few years ago, and we have been able to study it under all conditions of propagation and growth for three years, and it is certainly one of the most richly colored of all trees and shrubs, having yellow foliage, and keeps its foliage and its high color until November" (37).

The several sources of seed which contributed to the supply of *Ptelea* in European and English gardens were evidently sufficient to provide other varieties which interested horticulturalists. Even the earliest sources, from Virginia and

Fig. 2. *Ptelea trifoliata* L. Segments of roots (left); fragments of root bark (middle and lower right); root branch denuded of bark (upper middle to right). Point Pelee National Park, Ontario, Canada, *Bailey 5320*.

the Carolinas, might have furnished a variety of forms with respect to pubescence and other characteristics. In addition to the var. *variegata* Hort., Petzold and Kirchner (28) listed var. *heterophylla* Booth, var. *glauca* Booth, and *Ptelea mollis* Curtis.

Fabricius (10) described a variety with five leaflets ("*folia . . . quinata* und *angustiora*"), which Münchhausen (27) apparently translated to *Ptelea pentaphylla*. Specimens with occasionally five-foliate leaves occur frequently within the range of *Ptelea trifoliata* subsp. *angustifolia* (Benth.) V. L. Bailey in the southern Rocky Mountains of Colorado and New Mexico and southward in the Sierra Madre of western Mexico. Dippel (8) took up De Candolle's name, var. *heterophylla*, for this form and listed *Ptelea pentaphylla* as a synonym. The var. *glauca* Hort. (*P. glauca*) was a pubescent plant, considered by Dippel as a synonym of var. *pubescens* Pursh, and quite different from the nearly glabrous plant of northwestern Mexico which was later called *Ptelea glauca* Greene (13).

*Ptelea mollis* Hort. (Paris) was described as new by Jacques (17), according to Exell (9), who considered this to be a validly published name which had been overlooked. The plant was a softly pubescent type grown in the Garden of Plants at Paris, the origin said to be unknown. It is probably the same entity as the coastal plains plant of the southeastern United States, *Ptelea trifoliata* var. *mollis* T. & G. (*P. mollis* Curtis). Other names appearing in the literature of the period are *Ptelea viticifolia* Salis. (31) and *Ptelea trifoliata* f. *fastigiata* Hort. ex Schelle (33).

## Medicinal and Other Uses of *Ptelea*

The aromatic and bitter properties of the foliage and root bark of the hop-tree are such that this plant early came to the attention of physicians as of possible medicinal value. Indeed, according to the literature, *Ptelea trifoliata* L. had a fairly long history as a drug of considerable potential interest, especially in the early days of eclectic and homoeopathic practice in North America when emphasis was on the development of new remedies from indigenous plants. *Ptelea* root bark was listed as a tonic in the Homoeopathic Pharmacopoeia of the United States as late as 1941 (16), and it is reportedly still being used locally in certain areas by North American Indians. According to Merring (23), Indians of the "Amalgamated Indian Band" of the Walpole Island reservation, Ontario, Canada, use bark from the roots of *Ptelea trifoliata* in combination with root bark from three other plants. The mixture is used in powder form as a snuff, for headaches and nose congestion, or as a tea for treatment of muscular pains and stomach aches.

Although it is likely that native peoples of the regions where *Ptelea* occurs may have employed this plant medicinally or otherwise, and perhaps carried seeds with them from one locality to another, only one reference to aboriginal use has been found in the literature. Bennett and Zingg (2), writing on the Tarahumara, an American Indian tribe centered in the upper Río Urique drainage in the high Sierra Madre Occidental of southwestern Chihuahua, Mexico, describe its use as follows:

> "This plant is known as ápago among the Tarahumaras. The leaves are boiled and the decoction used as a bath or wash for the body or face in cases of rheumatism, a common ailment in the cold sierra. . . . The remedy is probably somewhat effective in alleviating pain due to the presence of an alkaloid."

This reference is of particular interest because it substantiates the record of the occurrence of *Ptelea* in the very inaccessible western mountains of Mexico. The only specimen seen from this area (*Palmer 152*, collected in 1885), has

fruits with finely pubescent seed-body, a characteristic not known to occur in any other place outside of California.

First reference to *Ptelea* in medical literature appeared in 1787 in "Materia Medica Americana" by Dr. David Schoepf, a Hessian physician of the British Army who spent some years in America following the American Revolution (19). As indicated in this work (34), the leaves were employed in the form of an infusion to be used internally as an anthelmintic or externally as a vulnerary.

Rafinesque is credited with being the first to introduce the plant into American medical literature (25) in his "Medical Botany" (30). This work was a compilation, with "medical indications," as the title page indicates, "taken from all sources, personal observations and communications, or from authors." Rafinesque lists uses as follows, "leaves vulnerary, vermifuge, in tea or poultice." This description was probably derived from Schoepf, whom he cites. In addition to Schoepf, he also refers to two other works, one by Howard and the other by Merát and de Lens. Howard speaks of the bark as an excellent stimulant or expectorant tonic, especially in agues. Merát and de Lens refer to the fruit as aromatic and bitter and an affirmed substitute for hops (25).

Employment of the fruits as a substitute for hops aroused considerable interest for a time, even to becoming a subject for investigation by the United States Department of Agriculture. At a meeting of the American Pharmaceutical Association in 1858, Dr. J. Browne of the Agricultural Department of the Patent Office was present as a guest speaker. After speaking of introductions of medicinal and other plants into this country, he stated, "The Department have turned their attention to *Ptelea trifoliata*, an indigenous shrubby tree, which is said to be a substitute for the hop, and is alleged to produce three times as much lupulin as the *Humulus*" (5).

The use of *Ptelea* fruits as a substitute for hops continued to be of general interest for some time, and for this purpose, the plant is said to have been grown quite extensively in parts of Russia (4). After a series of comparative studies on the glandular secretions of *Ptelea* (hop-tree) and of *Humulus* (true hop), Bigelow (4) concluded that although the glands are very different in structure, "the two plants have similar resinous secretions. . . . It [*Ptelea*] has the same bitter taste, but is without the aromatic principles which makes the bitterness of true hops so valuable."

The glands in *Ptelea*, as in members of the Rutaceae generally, are lysigenetic, appearing as cavities in the tissues of the fruits and leaves just below the epidermis. In *Humulus*, on the other hand, characteristically stalked glands cover the bracts of the flower heads. Bigelow's tests on the oleoresinous materials were apparently limited to a comparison of solubilities in water, ether, and alcohol. Results showed that the materials from both plants dissolved readily in alcohol and gradually in water, warm water in the case of *Ptelea*. In ether, however, granular material from true hops dissolved instantly while undissolved granules of *Ptelea* resin remained.

Bigelow's comments (4) that *Ptelea* "does the same thing" as true hops, that is, "it prevents the yeast from souring by checking the fermentation before all the sugar is converted into alcohol and carbon dioxide," indicates recognition of some sort of antimicrobial activity involved in the use of either *Humulus* or its substitute, *Ptelea*, in beer-making or in bread-making.

Recent studies in connection with screening tests for antibacterial substances in seed plants have included tests on the leaves, stems, and fruits of *Ptelea trifoliata*. Lucas, et al (22), reported that

in the tests made, leaves of *Ptelea trifoliata* showed positive antimicrobial action against *Mycobacterium tuberculosis* but not against three other test organisms. The stems and fruits were ineffective. These workers apparently did not investigate the root bark, which furnished the drug of choice during the period of its greatest use in medicine. Atkinson (1), after testing leaves, stems, or bark of a number of species in several groups of Australian flowering plants for antibacterial substances, reported that the family Rutaceae was the most active among those tested. *Ptelea* does not occur naturally in Australia and was not among the genera listed.

After its introduction into American medical literature (30), the use of *Ptelea* as a drug became more general, especially in "Eclectic practice" (21). Extractions obtained from the fresh bark of the root yielded an oleoresinous principle called ptelein, and it was so listed in John King's American Dispensatory of 1859 (18). Following a rather lengthy list of chronic conditions which might be found to respond to treatment with the drug from *Ptelea* bark, either used separately or in combination with other drugs, he sums up: "Ptelein is a tonic, and possesses other properties not yet satisfactorily understood, . . . a valuable medicinal agent which should receive the especial attention of the profession."

King (18), discussing the history of the drug, ptelein, said that it was first prepared "from the tincture of the bark by precipitation with water in the same manner by which podophyllin, iridin, eupurpurin, etc., are obtained." Such extract materials, which were not definite compounds, and "hence could not be accorded scientific nomenclature, were originally known as Eclectic resinoids" (21). Podophyllin, from the May apple (*Podophyllum*), was the first of this class of substances to be reported upon (15), and the directions for its preparation were used as a model for preparation of similar extracts for some time thereafter.

It was during the early period of active interest and testing of *Ptelea* as a drug that it was introduced into homoeopathic literature. Dr. E. M. Hale, lecturer in the Hahnemann School of Medicine in Philadelphia, is credited with first introducing it in 1868 (14). In the first edition of the United States Homoeopathic Pharmacopoeia (38) the "active principle" was described as "an indefinite extractive, ptelein," and the "part used" was indicated as "equal parts of bark of the root and the leaves." Later, the name, ptelein, was dropped and the more modern indication of the drug adopted. Felter and Lloyd (11) listed it as "the bark of the root of *Ptelea trifoliata* Linné." "Medical uses," in this work were still rather indefinite, as may be seen from the list of "actions" attributed to it and the chronic nature of the ailments which were reputed to be benefited. Directions for use were various, the drug sometimes being used alone, or more often, in combination with other drugs. It was used "in powder, tincture, or extract; dose of powder ten to twenty grains, three or four times a day; of the tincture, one or two fluid drachms; of the extract, five to ten grams; specific ptelea one to twenty drops."

This increased interest in *Ptelea* and its growing reputation in American medicine, particularly among physicians of the western states, prompted several workers to undertake investigations to determine the chemical constituents or active principles for the treatment of disease (35, 36). Felter and Lloyd (11) summarized some of the work as follows:

> "Mr. George Smyser . . . believes the active properties of the root to be due both to a volatile oil and an acrid soft resin, soluble in alcohol and ether: the leaves yield a bitter infusion in water, resembling in taste that of hops and containing tannic and gallic acids. The fruit likewise is bitter and

yields the same resins as the root.

"Justin Steer . . . believes the bitterness of the bark and its virtues as a tonic to be due to berberine.

"E. Schulze (Jahresb. der Pharm., 1896, p. 510) found the root of *Ptelea trifoliata* to contain the base arginine, a constituent of germinating seeds of *Lupinus luteus* and other plants. . . ."

Wehmer (39) mentions arginine in the root and saponin in the leaves, but this was probably not first-hand information. Steer's report (36) of the alkaloid berberine in *Ptelea* root bark is of interest in light of recent trends in pharmaceutical investigations accompanying an increased importance ascribed to alkaloids. The actual presence of berberine in *Ptelea,* however, has not been confirmed.

Considerable attention is now being given to searching new plant sources for any that may prove to have value in medicine. Willaman and Schubert (40) indicate that in the Rutaceae, which is one of the families most examined chemically, only thirteen per cent of all of the species have been tested. Of the 47 genera of Rutaceae which have been tested for alkaloid content (41), positive tests were given by 71 species in 32 genera, while 117 species in 28 genera tested negative. *Ptelea* was not among those tested.

There have been some records of ill effects from the use of *Ptelea*. Hale tested the physiological action on a number of "observers," who took from one grain to a scruple (twenty grains) of "ptelein," and reported (14) the following disturbances: "mental depression and confusion; frontal headache, vertigo (giddiness or dizziness); contraction of the pupil; aural pains with swellings of the lymphatics; tongue sore, yellow-coated; ptyalism (salivation); voracious appetite; nausea, with pressure in the stomach as of a stone; gripping colic; great urging followed by copious diarrhoeic stools; urine increased; heart's action increased; general restlessness and prostration, followed by chilliness and fever."

According to Felter and Lloyd (11), "a tincture of *Ptelea* made in whiskey . . . is said to cause, in many instances where it has been used, a troublesome external erysipelatous inflammation, either general or local, but which, if the use of the tincture is persisted in, finally disappears, and the patient becomes at the same time permanently cured of the disease for which he was treated." They conclude that "this would certainly indicate other valuable properties of this plant than those with which we are acquainted, which deserve a further and thorough investigation."

A dermatitis believed to have been caused by leaves of *Ptelea angustifolia* growing in a park in Rochester, New York, was investigated by Muenscher and Brown (26). This is a form from the southwestern United States which was introduced into the Rochester park. After experiments, in which crushed leaves of *Ptelea angustifolia, Ruta graveolens,* and *Dictamnus albus* were applied to separate areas on the arms of volunteer subjects, it was concluded that "contact with leaves of *Ptelea angustifolia* causes a dermatitis in susceptible individuals," and that the dermatitis "is very similar to that produced by *Dictamnus albus* and *Ruta graveolens*."

Other representatives of the orange family have been known to cause skin eruptions. Leaves of *Ruta graveolens,* one of the sources of the glycoside rutin (antihemorrhagic or vitamin P factor), have a strong, disagreeable odor and a bitter, acrid, pungent taste. "They bear numerous short-stalked glands containing very irritating oil which may blister the skin if handled in the fresh state" (7). "The Spanish *Ruta montana* is so acrid that it is said to blister the hands that gather it through three pairs of gloves, and produces ulcerous pustules when applied to the naked skin" (12).

I have seen no references indicating ill effects caused by contact with leaves of the eastern *Ptelea trifoliata*. It appears to be true, and is perhaps of some significance, that plants growing in the more mesic areas of the eastern United States have generally small, inconspicuous glands and are without the strong mephitic odor characteristic of those of the western United States. This is true, at least in my experience, with the plants of the Great Lakes region and of the southeastern United States where I have collected, as compared with those from southern Colorado, Arizona, and California. Although I have not had opportunity to examine freshly collected specimens of *Ptelea* from other areas of the west, including Mexico, the size and prominence of the glands, as seen microscopically, is similar to that in leaves of plants having a strong, pungent odor. A few herbarium labels with notations such as "with skunk-like odor," tend to bear out the generalization in at least a few cases.

In specimens I have obtained east of the Mississippi River, the foliage, at the time of collection, had only a mild lemon odor, and the flower clusters emitted a sweet perfume reminiscent of orange blossoms. The roots did not seem very strongly pungent at first, but if some were allowed to remain for a time in a closed room, the air soon became very unpleasant with a peculiar disagreeable odor similar to that of the crushed herbage of *Ailanthus*.

The only indication in the literature as to the geographical origin of the *Ptelea* drug material is in the distribution or habitat notes such as "indigenous to North America, ranging from Pennsylvania westward to Wisconsin and southward to Florida and Texas" (25) or "common to this country, growing more abundantly west of the Alleghenies" (11). In all cases, the botanical source is indicated as *Ptelea trifoliata*, which would indicate that the eastern form was the one generally used. Felter and Lloyd (11) note also that "a related species, *Ptelea angustifolia*, is indigenous to Colorado."

It is reasonable to suppose that physicians making use of the fresh *Ptelea* root bark as a drug would take the material closest at hand, and there is some evidence that western physicians may have found the remedy more useful in their practice than those of the east. Smyser's statement (35) that "the bark of the root of this plant is used to some extent by eclectic physicians of the west as a tonic in intermittent and remittant fevers" is somewhat indicative. Later Steer (36), in an introductory statement preceding his report on analytical tests, relates, "The bark of the root has, of late years, acquired considerable reputation among physicians of the western states as a remedy for dyspepsia, and also as a tonic." He cites O. F. Potter, M.D., of St. Louis, Missouri, who claimed (29) that he had had over ten years of experience in the use of *Ptelea* bark and highly recommended it to the profession, "as a tonic following the use of quinine and in all grades of fevers, also in cases of general debility connected with gastro-enteric irritations."

Neither the Pharmacopoeia of the United States (U. S. P.) nor the National Formulary (N.F.) has ever recognized *Ptelea* as an official drug, and interest in its use naturally declined along with the gradual decrease in importance of homoeopathic remedies. During the first quarter of the twentieth century *Ptelea* was again called to the attention of pharmacists in a different role, when the root bark was found on the American drug market as a spurious substitute for *Euonymus* root bark (42). The name was listed in the index of the sixth and seventh editions of the United States Pharmacopoeia, 1882 and 1894 respectively, but referring only to a note of

caution against mistaking it for *Rhus toxicodendron* L., with which the leaves may be easily confused.

**Summary**

Historically, the genus *Ptelea* is of interest from several standpoints. A review of the literature brings to light interesting stories of its discovery in North America during colonial times, the introduction into Old World gardens and garden literature, and the subsequent attention aroused by its bitter and aromatic properties as of potential use in medicine. It was one of the plant genera which came under the surveillance of physicians during the early days of American medicine when a search was being made for new remedies from the indigenous plants.

After first mention of the use of the leaves of *Ptelea* as a vermifuge and vulnerary by Schoepf in 1787 and by Rafinesque in 1830, considerable interest was expressed among American "eclectic" and homoeopathic physicians, and it was variously listed in the middle and later nineteenth century literature as "ptelein" or *Ptelea* bark, reputed to be useful as a tonic and for treatment of fevers and various types of chronic ailments. Fruits were used as a substitute for hops.

Results of chemical analyses during the period of interest indicated active constituents variously as berberine, tannic and gallic acids, arginine, saponins, resins, volatile oil, etc., but these findings have not been confirmed. No recent analytical work has been done. Antibacterial action of the leaves against *Mycobacterium tuberculosis* has been reported.

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# Progress in Developing Superior Hevea Clones in Brazil

CHARLES H. T. TOWNSEND, JR.[1]

## I. Introduction

The nine recognized species of the genus *Hevea* originated chiefly in the districts drained by the Amazon River and its tributaries. The area of the territory in which the rubber tree grows is estimated to be about 2,250,000 square miles, of which 1,487,000 are in Brazil, 200,000 in Bolivia, 250,000 in Peru, 75,000 in Ecuador, 150,000 in Colombia, 30,000 in Venezuela, and 58,000 in the Guianas.

The genus *Hevea* is, perhaps more than any other, characteristic of the Amazon basin, since the limits of this region just about coincide with its geographic area. All of the nine known species are found in Brazil. Two species are found in Bolivia, 5 in Peru, 2 in Ecuador, 5 in Colombia, 3 in Venezuela, and 2 in the Guianas. Most of the wild rubber and all of the cultivated rubber produced in the Amazon basin is obtained from species of *Hevea, H. brasiliensis* Muell. Arg. being by far the most important source.

In 1875, Henry Wickam collected a shipment of *Hevea brasiliensis* seeds from the Boim district bordering on the Tapajós River in Brazil. From the 70,000 unselected jungle seeds collected, 2,397 seedlings were started at the Royal Botanic Gardens, Kew, in England. About 1,900 of these were shipped to Ceylon in 1876, and became the foundation of the rubber-growing industry in the Far East.

South American leaf blight has long been considered the most destructive pest of the *Hevea* rubber tree. Leaf blight seldom causes severe damage to scattered *Hevea* trees growing in their jungle habitat. However, when trees are planted row upon row in nurseries and fields, the opportunity for the development and spread of disease is greatly increased. Thus, the leaf blight, which had hardly been noticed when most of the world's rubber came from wild trees growing in the Amazon Valley, first presented a serious problem when attempts were made to grow *Hevea* trees on plantations in South America early in the present century. The disease spread from the scattered jungle trees to the planted areas and destroyed most of them. Thousands of acres were ruined and abandoned. Following the initial failures, interest in rubber production in tropical America waned and support for a sustained effort to solve the leaf blight problem was long delayed. In the meantime, the world became dependent on Far Eastern sources for 97% of its crude rubber. There, in the absence of leaf blight, a thriving rubber-growing industry has been developed.

## II. South American Leaf Blight

**a) Life History of the Fungus.** The leaf blight caused by *Dothidella ulei* P. Henn. is widely distributed in the Amazon Valley and throughout most of Central America. The fungus appears to be specific for *Hevea* and no other host is known.

The fungus makes its first appearance on the young leaves as they unfold from the bud, as well as at any time before the leaf reaches maturity. The severity of the infection, however, decreases with the advance in age. Translucent spots, which soon become olive or blackish green, ap-

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[1]Horticultural Advisor, International Cooperation Administration, United States of America Operations Mission to Brazil. Present address: USOM, American Embassy, Guatemala City, Guatemala.

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pear on the young leaves. At times only a portion of the leaf at the edges or at the tip or in the region of the leaf glands at the base is infected. The unequal stress caused by the continued development of the uninfected parts tears and splits the infected portion, so that it may fall away or leave irregular holes extending toward the midrib. The leaf may then present a very ragged appearance, rolling inward from the edges and upward from the tip, so that the leaves on a twig may be bunched or snarled. When the infections occur sparingly and do not coalesce, the infected tissues become discolored and fall out, with the resulting shot-hole effect because of the rapid development of the leaf. At other times these initial spot infections, which are usually at first scattered either along the edges or promiscuously over the whole surface, may rapidly coalesce until the entire leaf surface is involved. The edges then begin to roll, and the entire leaf crumples up, becomes black, and hangs limp from the twig as though recently scorched by fire, and finally falls. The petioles, young shoots, inflorescences and fruit are also attacked by the fungus, but less frequently than the leaves. Curvature or spiral twisting may occur on infected petioles from the unequal stress caused by the continued development of the uninfected part. Dark canker-like patches may also be produced by the fungus on the leaf venation, petioles, and young shoots. Under humid conditions the fungus may multiply rapidly. Severe defoliation may result in dieback of the terminal shoots. *Hevea* trees of any age may be killed by successive defoliations.

**b) Control with Fungicides.** Effective control of leaf blight by fungicidal sprays has been demonstrated. Among the copper, sulfur, and organic fungicides tested, the insoluble copper compounds proved most practical under preliminary trials. Later trials conducted extensively in Costa Rica indicated that zinc ethylene bisdithiocarbamate (trade names Dithane Z-78 and Parzate) is superior to the insoluble copper compounds. Spreaders and stickers increase the efficiency of all the spray mixtures. Although it has been demonstrated that leaf blight can be controlled on producing trees by the use of fungicides, economic considerations make it necessary to limit spraying operations to nursery plants and very young plantation trees.

### III. Selection of Resistant Clones

The blight-resistant clones that first entered into commercial use were selected on the Ford Plantations in Brazil. Despite the fact that South American leaf blight had already destroyed rubber plantations in Trinidad and the Guianas, and the disease had been reported in the Amazon Valley as early as 1904, the Ford Motor Company initiated a large scale planting program in Brazil in 1927. An area in the State of Pará, located on the right-hand margin of the Tapajós River, about 125 miles from its confluence with the Amazon, was chosen and became known as Fordlandia. The Company was soon confronted with the necessity of developing *Hevea* planting material which combined high yield with resistance to leaf blight. Such material was nonexistent at the time. The Ford Company began to introduce and establish on the Fordlandia Plantation propagating material of outstanding jungle selections, various *Hevea* species, and regional strains of *H. brasiliensis* (the commercial rubber tree). Seeds were brought in from the Acre Territory, from the Solimoes, Machado and Tapajós rivers, and from the region of Belém. More than a million seedling trees were planted in the field at Fordlandia. The bulk of the seeds came from the Tapajós River area and produced no trees with resistance to leaf blight. However, among smaller populations of trees originating in the Belém area and up-river seeds, dozens of individuals were observed which suffered no

damage when leaf blight defoliated the adjacent trees. Another group of trees showing resistance to leaf blight came from budwood taken from outstanding jungle trees growing in the Acre Territory and the Rio Negro area of the Amazon Valley.

From the material introduced and established on the Fordlandia Plantation it was possible to isolate several hundred blight-resistant individuals. It has been found that the most resistant individuals generally occur in the upper part of the Amazon Valley. The population occurring along the lower Tapajós River (the area from which seeds were obtained to initiate the rubber-growing industry in the Far East) has proved extremely susceptible. None of the high-yielding clones developed in the East and tested in the Americas has shown resistance to leaf blight. The implications for the millions of acres of *Hevea* now growing in South East Asia are obvious if *Dothidella ulei* should spread there. Preliminary tests conducted on the Fordlandia Plantation indicated that all the blight-resistant selections gave low yields of rubber. A collection of high-yielding *Hevea* clones from the Far East was introduced and successfully established. A few thousand buddings with these clones were made in the field. It soon became apparent, however, that leaf blight would prevent the budded trees from making normal growth.

In 1934, extension of the field areas at Fordlandia was discontinued and a new site approximately 90 miles farther down the Tapajós River was selected. The Belterra Plantation is situated on the right-hand margin of the Tapajós about 35 miles from its confluence with the Amazon River. All of the better blight-resistant selections made at Fordlandia were established in special plots at Belterra. Additional high-yielding clones from the Far East were introduced and successfully established. *Hevea* species not previously represented, and new regional strains of *H. brasiliensis* were subsequently brought in for study. The wealth of *Hevea* material assembled on the Ford Plantations from various sources made possible what was to become an extensive and comprehensive breeding program.

### IV. Breeding Program

**a) The Hevea Flower.** *Hevea* flowers appear simultaneously with the new foliage during annual leaf change, and are borne near the terminal end of the new twigs. The inflorescence is a leafless panicle having both male and female flowers. The female flowers occur at the ends of the stronger axes; the male flowers appear on the lesser branches. The number of male flowers is always much greater than that of the female flowers. All *Hevea* species have either intense yellow, yellowish white, or pale brownish yellow flowers with the exception of *H. spruceana* Muell. Arg. which has reddish brown or brownish violet flowers.

The female flower is larger than the male. The perianth is a hairy, bell-shaped, five-lobed calyx. The receptacle is broadened into a disk which is green externally. The ovary is superior and usually three-celled with a correspondingly three-lobed sessile stigma. Once the calyx opens, receptivity of the ovary is limited to about 20 hours.

The receptacle of the male flower is not expanded into a broad disk. The perianth is, as in the female, a hairy, bell-shaped, five-lobed calyx. A staminal column with sessile anthers, placed about half-way up the column, is found in the center of the male flower. The number of anthers and their arrangement on the column vary according to the species. Each anther contains two pollen sacs which split longitudinally. The pollen grains are smooth and sticky and are not air-borne. Pollen, once collected and kept under normal conditions, undergoes an appreciable loss in viability within 4 to 6 hours.

**b) Hand Pollination Technique.** In preparing an inflorescence for pollination, all the male flowers and opened female flowers are removed, only the unopened female flowers being allowed to remain. When the female flower reaches the proper stage, the perianth lobes are gently forced apart with a pair of tweezers and the staminal column of a mature male flower of the selected male parent is inserted and placed in contact with the stigma. A plug of cotton wool, sealed with a drop of latex, is used to keep it in place. Once fertilization has occurred, the fruit-wall begins to develop and in about three months reaches full growth. The seeds then begin development and fill the space between the carpels. About five months after pollination, the fruit bursts open and the ripe seeds are released. The fruit may be harvested when the epicarp turns from green to brown. It is a good practice, however, to enclose the fruit in a mesh bag about four months after pollination in order to retain the seeds in case dehiscence of the valves of the carpel should occur before harvesting. The success of hand pollination, under normal conditions, varies from 0.2% to 20%, and averages about 4%. Success depends a great deal on the degree of fertility of the individual. Some clones are self-sterile, while others are to a certain extent self-fertile.

**c) Breeding.** The principal characters of the desired type of *Hevea* tree are as follows:

1) Vigor. Vigor as represented by annual girth increment is a desirable character in clones, it improves morphological characteristics, and reduces the period between planting of the trees and the time they can be brought into production (normally between the sixth and seventh year).

2) Yield. Plantation economics require that yield per acre should be as large as possible. Under most conditions an average yield of 1,000 pounds per acre per year is considered satisfactory.

3) Resistance to Disease. Resistance to disease is an important requisite when selecting *Hevea* clones for use in regions where the more serious diseases are prevalent, or where ecological conditions would favor their development should they appear at some future date. Leaf blight may kill *Hevea* trees of any age by successive defoliations.

4) Satisfactory Bark Characteristics. The bark should be thick and smooth, and should not contain many stone cells. Tapping of rubber trees involves the periodic paring off of successive layers of bark almost to the cambium on a left spiral cut, inclined at an angle of 25 to 30 degrees from the horizontal. This operation is usually begun when the tree has attained a girth of 18 inches at 40 inches from the union in the case of buddings, and 20 inches from the root collar in the case of seedlings. After about 8 years of tapping on virgin bark the panel is exhausted and tapping is then begun on renewed bark. Yield on the renewed bark should be satisfactory.

5) Satisfactory Tree Form. Selections with a tendency to weak junctions of lateral branches should be excluded. Clones with a tendency to fluting of the trunk to an extent where tapping is made difficult should be eliminated.

6) Satisfactory Latex Properties. Latex should preferably be white, not prone to precoagulation, and with a satisfactory mechanical stability.

7) Uniformity of Trees Within Clones. In order to obtain a uniform stand of high-yielding trees over an area budded with a given clone, yield and vigor should present as even a pattern for the clone as possible before final selection is made.

A breeding program designed to produce plants combining high yield with disease resistance was started in 1937. The two radically different groups of *Hevea* clones provided the required ma-

terial. One consisted of the best high-yielding selections from millions of trees growing in the Far East. These selections are susceptible to leaf blight and had to be protected by fungicidal sprays. The other consisted of blight-resistant clones selected from large populations of seedling trees growing in the Amazon Valley. These have a low yield of rubber.

The rubber selection and breeding work, originally started by Ford in 1935, was considerably extended when the United States Department of Agriculture, through its Program of Rubber Plant Investigations, started a cooperative breeding program with the Instituto Agronómico do Norte (a Brazilian government research center located at Belém, Pará) and the Ford Plantations at Belterra. This cooperative effort involving the United States Department of Agriculture was started in 1942 and continued until 1954. Simultaneously the Department of Agriculture was conducting selection and breeding work on a smaller scale in Costa Rica and Guatemala. More than a million hand pollinations were made. A total of 133,172 cross-pollination progenies were produced and tested for resistance to leaf blight at Belterra. From these, 12,007 blight-resistant clones were selected. Of these, 10,686 have been budded to the extent of five to ten field trees of each selection. The oldest of these clones are now undergoing yield tests. By 1958, a total of 585 acres had been utilized at Belterra to establish cross-pollination progenies in the field for observation and determining of yields of rubber. After the Ford Company turned the plantations over to the Brazilian government in 1946, the *Hevea* breeding work at Belterra became the responsibility of the Instituto Agronómico do Norte. Assistance by technicians of the International Cooperation Administration has been extended on the agronomic, genetic, and pathological phases of the program.

A number of groups of clones of outstanding resistance and vigor have been produced by crossing certain highly resistant Ford clones with blight-susceptible Eastern clones. Within each group of clones produced by crossing a blight-resistant Ford clone with a susceptible Eastern clone, the plants range from highly susceptible to resistant. The percentage of resistant plants, however, varies greatly, depending on the Ford clone used in making the cross. When moderately resistant clones are crossed with Eastern clones, the progenies are predominantly susceptible.

Certain clones of *Hevea benthamiana* Muell. Arg. have given especially noteworthy performance as blight-resistant breeding clones. These were established at Belterra with budwood from Rio Negro jungle trees and have proved immune to all variants of the leaf blight fungus to which they have been exposed. A high percentage of the progenies from crosses between *Hevea benthamiana* clones and various Eastern clones has proved immune or highly resistant to leaf blight, and many selections from these families have demonstrated exceptional vigor. A number of these selections, when backcrossed to the blight-susceptible Eastern parent, have produced progenies in which more than 50% of the seedlings have shown a high degree of resistance to leaf blight. Furthermore, when these backcrosses are backcrossed for the second time to the high-yielding susceptbile Eastern parent, families hae been produced in which over 10% of the progenies still prove resistant to leaf blight. Selections made from these owe ⅞ of their origin to high-yielding Eastern clones.

Based on the performance of 43 selections, originating from crosses between *Hevea pauciflora* Muell. Arg. and a high-yielding susceptible Eastern clone, it appears that certain individuals of this species will be of considerable value as breeding stock which transmit exceptional

vigor and a high degree of disease resistance to a majority of their progenies.

All of the original seedling selections made by Ford were given either F, FA or FB prefixes; all Ford crosses bear an FX prefix. Crosses made under the auspices of the Instituto Agronómico do Norte were assigned an IAN prefix. Considerable data on the yields of rubber have been obtained from $F_1$ selections derived from crosses between Ford and Eastern clones. It is obvious, however, that a large majority of the progenies of such crosses will, like the original Ford clones, have low yields of rubber. Under Belterra conditions, a very small percentage of the $F_1$ selections tested has indicated yields which compare favorably with those of Eastern clones.

From the large population of cross-pollination progenies tested to date, the following conclusions can be drawn:

1) Certain blight-resistant clones, when crossed with susceptible clones, transmit high disease resistance to a majority of their progenies.
2) Some blight-resistant $F_1$ selections have proved to be more vigorous than either parent.
3) Most $F_1$ selections, originating from crosses between resistant *Hevea brasiliensis* clones and Eastern clones, when backcrossed or outcrossed to a high-yielding susceptible Eastern parent, produce no resistant progenies.
4) Certain $F_1$ selections, derived from crosses between *Hevea benthamiana* clones and Eastern clones, when backcrossed or outcrossed to a high-yielding susceptible Eastern parent, have given more than 50% resistant progenies.
5) Some first backcrosses and outcrosses, with *Hevea benthamiana* and an Eastern clone as parents in the primary cross, when backcrossed or outcrossed to a high-yielding susceptible Eastern parent for the second time, have produced families in which over 10% of the progenies are resistant to leaf blight.
6) A progressive loss in vigor, to a certain extent, occurs when backcrossing or outcrossing to susceptible high-yielding Eastern clonal parents is carried through the second and third generations.
7) A very small percentage of the $F_1$ selections has indicated promising yields.

Preliminary data for the yields of rubber have been obtained from a few first backcrosses and outcrosses. It is too soon, however, to form an opinion on the potential yields of this type of material. Indications are, however, that average yields will be greater than those of the $F_1$ selections. Large groups of selected progenies of crosses made since 1948 will begin to come into production in approximately two years. These clones consist largely of $F_1$ selections backcrossed or outcrossed to high-yielding Eastern parents and should produce much improved, blight-resistant clones for commercial use.

Third generation material consisting of second backcrosses and outcrosses has been produced. However, due to the immature age of this material, it has been possible to determine only the disease-resistance characteristics; the yield of rubber and secondary characters have yet to be determined. These selections owe ⅞ of their origin to high-yielding Eastern parents. It is highly probable, therefore, that some of them will have good yield in addition to their demonstrated blight resistance.

Growing conditions at Belterra are quite different from most rubber-growing areas even in Brazil. The advisability of establishing the most promising cross-

pollination progenies under other conditions of environment for observation was recognized. In 1945, the first of several exchanges of plant material was made between Brazil and Costa Rica. From Costa Rica propagating material was made available to other countries in Latin America. The better selections were also established in field plots at the Instituto Agronómico do Norte and on the Goodyear Plantation in the State of Pará, at the Instituto Agronómico do Leste and on the Firestone Plantation in the State of Bahia, and at the Instituto Agronómico de Campinas in the State of São Paulo.

## V. Discussion

Breeding *Hevea* plants which combine high yield with resistance to disease is a long-range project, especially when starting with high-yielding blight-susceptible material on one side, and low-yielding blight-resistant material on the other. Under favorable conditions, the minimum time required for each generation is about as follows:

| | |
|---|---|
| To determine resistance to disease | 1 year |
| To reach commercial tapping size | 6 years |
| To determine yield and secondary characters | 2 years |
| Total | 9 years |

Starting with the type of *Hevea* material which was available, it appears that breeding and selecting will have to be carried through the third generation before the characters of high yield and disease resistance can be satisfactorily combined. Even then, it may be found necessary to double cross third generation lines in order to reintroduce vigor.

*Hevea* plant improvement and breeding involves great expense and must be considered as a long-range project. Continuance and support from administrative organizations is essential in carrying out such a program.

Rubber planting material, consisting of $F_1$ clonal selections developed on the Belterra Plantation, has been distributed by the Instituto Agronómico do Norte throughout Brazil and is making an important contribution to the rubber development program. Blight-resistant planting material with a yield potential of about 600 pounds per acre per year, as compared to 1,000 pounds or more for the better Eastern clones, is being used for planting on small farms where top-budding is not practical. For the immediate development of commercial plantations, top-budded or three-component trees will still have to be used to some extent. Base budding to insure high-yielding trees has long been a practice on rubber plantations but, prior to 1942, top budding was used on only a few experimental trees. In this process a tree of three components is produced; that is, a high-yielding susceptible clone, budded onto a root-stock, is in turn budded with a blight-resistant clone at a sufficient height to ensure a suitable tapping panel.

Several exchanges of *Hevea* planting material have taken place between Brazil and Costa Rica. This material consisted of $F_1$ selections and clones derived from $F_1$ selections backcrossed or outcrossed to high-yielding Eastern parents.

The Far Eastern rubber-plantation industry recognizes the possibility of having to cope with South American leaf blight sooner or later. Should the disease be introduced, there would be no economic means of saving the stands of mature rubber trees. Plantings ranging in age from 1 to 6 years could be saved by top budding with blight-resistant *Hevea* clones. The same danger threatens the rubber plantation industry in Africa. In 1952, Malaya and Brazil negotiated an exchange of *Hevea* planting material. The rubber Research Institute of Malaya received 25 clones of jungle seedling selections and some of the first primary crosses made by Ford. Brazil received in return, through the Instituto Agronómico do Norte, 25 high-yielding blight-susceptible clones from Malaya. In 1957, Ceylon and Brazil concluded negotiations

for an exchange of *Hevea* planting material. A total of 26 second outcrosses were made available to the Rubber Research Institute of Ceylon, and in return the Instituto Agronómico received 26 high-yielding Ceylonese clones. At present in the Far East plans are being considered for conducting tests for resistance to leaf blight at a suitable location somewhere in the Western Hemisphere, on *Hevea* material developed from the recent introduction of blight-resistant clones from Brazil.

Approximately 96% of the rubber currently produced in Brazil is derived from wild trees growing in the Amazon Valley. Annual production for the last five years has remained more or less static and has averaged about 23,000 metric tons per year. Brazil's post-war increased consumption of rubber has necessitated the importation of large quantities of crude rubber from the Far East. The annual deficit is rapidly approaching 30,000 metric tons.

Brazil is directing renewed efforts to establish a sound rubber-growing industry based on the following:

1) The need of filling the nation's rubber requirements in view of its expanding industry.
2) The need for an economically sound rubber-plantation industry closer to the centers of consumption in the Western Hemisphere.
3) The possibility that the present sources of natural rubber in the Far East and Africa might be attacked by South American leaf blight.

Brazil unquestionably has made important contributions to the rubber-growing industry. Achievement of the objectives of the breeding program will, without doubt, make available greatly improved *Hevea* planting material.

## VI. Summary

Large groups of *Hevea* material from various sources have been assembled on the Belterra Plantation for breeding purposes. All of the blight-resistant jungle selections have a low yield. All high-yield clones introduced from the Far East are susceptible to leaf bight. Some *Hevea benthamiana* selections have given a noteworthy performance as blight-resistant breeding clones. Certain *Hevea pauciflora* selections are promising breeding clones.

More than 130,000 cross-pollination progenies have been produced and tested for resistance to leaf blight at Belterra. From these, over 12,000 blight-resistant clones have been selected, and more than 10,000 have been budded to the extent of 5 to 10 field trees of each selection for observation and determining yields of rubber.

A very small percentage of the $F_1$ selections show promising yields. Preliminary data obtained from a few first backcrosses and outcrosses indicate that average yields will be greater than those of the $F_1$ selections. Large numbers of back- and outcrosses will begin to come into production in approximately two years. These clones consist largely of $F_1$ selections backcrossed or outcrossed to high-yielding Eastern parents and should produce much improved, blight-resistant plants for commercial use. Third generation material consisting of second backcrosses and outcrosses has been produced. Due to the immaturity of this material, it has been possible to determine only the disease resistance factor. These selections owe ⅞ of their origin to high-yielding Eastern parents. It is probable, therefore, that some of them will have superior yield and resistance to leaf blight. Costa Rica, Ceylon, and Malaya have negotiated exchanges of *Hevea* planting material with Brazil.

Brazil has made important contributions to the rubber-growing industry. When all of the objectives of the breeding program are achieved, there should be available greatly improved *Hevea* planting material to the rubber-growing industry of the world.

# A Comparison of Chemical Properties of Seeds of Gossypium Species

VERNON L. FRAMPTON,[1] WALTER A. PONS, JR.,[1] and THOMAS KERR[2]

The possibility of utilizing gene pools from wild cottons in the improvement of commercial varieties, with special reference to seed quality, has led to the quantitative analysis of seeds from several species of *Gossypium*. The primary purpose of the study was to supply data for *Gossypium* species that may serve to aid plant breeders in their selections of breeding materials.

Seed from the species listed in Table I were grown in Iguala, Mexico, in 1956-57, and shipped to New Orleans where they were stored under refrigeration until prepared for analysis. Species names used follow the classification of Hutchinson, Silow, and Stephens (3).

The seed was decorticated and ground in a Wiley mill[3] to pass through a 20-mesh screen. The ground materials were analyzed for moisture, oil, and nitrogen by appropriate methods of the American Oil Chemists' Society (1); for lysine by the method of Conkerton and Frampton (2) after prior removal of the oil by pentane extraction; and for total gossypol by the procedure of Pons, Pittman, and Hoffpauir (4). The identity of gossypol in the extracts of the seed of the several species was established by a spectrophotometric examination of the aniline derivative produced in the analytical procedure. Spectra typical of those of dianilinogossypol were obtained with all of the seed samples.

Refractive indices were determined with an Abbé refractometer on oils extracted from the kernels with commercial hexane. Ultraviolet and visible absorption spectra of the extracted oils were obtained with a Cary recording spectrophotometer, using cyclohexane as the solvent for the oils and as the reference solvent.

The spectrophotometric data recorded in Table II are expressed in terms of the absorption of the oils, as defined by the relationship

$$a = A/bc,$$

where a is the absorptivity, A is the absorbance equal to log $I_o/I$, b is the cell length in cm., and c is the concentration of the oil in grams per liter of cyclohexane.

Although it was not possible to establish the ranges in values for nitrogen, gossypol, and lysine that are characteristic for each of the species studied, it is evident that there is a substantial and real difference in the gossypol contents of the different species. The range is from 0.13% for *G. stocksii* to 6.64% for *G. klotzschianium* var. *davidsonii*. If one may assume that the variation from the mean of values that may be expected for any one species is comparable with that encountered in *G. hirsutum*, the gossypol value for *G. arboreum* does not differ from that of Upland cotton. The gossypol contents of *G. raimondii*, *G. harknessii*, and *G. armourianum* are somewhat higher than that of Upland cotton.

[1]Southern Regional Research Laboratory, one of the laboratories of the Southern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture, New Orleans, Louisiana.

[2]Cotton and Cordage Fibers Research Branch, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, Beltsville, Maryland.

[3]It is not the policy of the Department to recommend the products of one company over those of any others engaged in the same business.

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TABLE I
ANALYSIS OF KERNELS OF *Gossypium* SPECIES

| Species | Oil $n^{25}_D$ | Moisture-free basis | | | Moisture- and oil-free basis | | Lysine g./16 g. N |
|---|---|---|---|---|---|---|---|
| | | Oil | Nitrogen | Gossypol | Nitrogen | Gossypol | |
| | | % | % | % | % | % | |
| *G. arboreum* L. | 1.4716 | 36.8 | 5.41 | 1.27 | 8.56 | 2.01 | 4.4 |
| *G. anomalum* Wawra & Peyr. | 1.4711 | 31.4 | 6.37 | 0.47 | 9.28 | 0.69 | 4.5 |
| *G. triphyllum* (Harv.) Hochr. | 1.4717 | 27.6 | 8.12 | 0.28 | 11.22 | 0.39 | 4.2 |
| *G. stocksii* Mast. | 1.4723 | 29.3 | 7.29 | 0.13 | 10.31 | 0.18 | 4.3 |
| *G. aridum* (Rose & Standl.) Skovsted | 1.4699 | 34.4 | 5.92 | 3.55 | 9.02 | 5.41 | 3.8 |
| *G. armourianum* Kearney | 1.4678 | 37.7 | 5.77 | 2.36 | 9.26 | 3.79 | 4.0 |
| *G. harknessii* Brandeg. | 1.4741 | 39.7 | 5.63 | 2.63 | 9.34 | 4.36 | 4.0 |
| *G. klotzschianium* var. *davidsonii* (Kellogg) J. B. Hutch. | 1.4750 | 33.2 | 5.14 | 6.64 | 7.69 | 9.94 | 4.1 |
| *G. raimondii* Ulbr. | 1.4720 | 31.9 | 6.53 | 2.51 | 9.59 | 3.68 | 3.8 |
| *G. thurberi* Todaro | 1.4722 | 34.9 | 5.66 | 3.27 | 8.69 | 5.02 | 4.1 |
| *G. gossypioides* (Ulbr.) Standl. | 1.4717 | 27.9 | 7.14 | 0.39 | 9.90 | 0.54 | 4.2 |
| *G. hirsutum*, L. commercial varieties | | | | | | | |
| Paymaster 54 | 1.4717 | 40.8 | 5.63 | 1.24 | 9.51 | 2.09 | ... |
| Deltapine 15 | 1.4712 | 38.1 | 6.12 | 1.44 | 9.89 | 2.32 | 4.3 |

while the values for *G. aridum* and *G. thurberi* are in the next higher class. The gossypol content of *G. klotzschianium* var. *davidsonii* is inordinately high, in comparison with those obtained for the remainder of the species listed. On the other hand, *G. triphyllum, G. stocksii,* and *G. gossypioides* are low-gossypol species.

The oil values fall within the range normally encountered with varieties of *G. hirsutum. G. gossypioides, G. stocksii,* and *G. triphyllum* may contain less oil. The variation in unsaturation of the oils as indicated by the range in indices of refraction is probably no greater than that encountered in oils from varieties of *G. hirsutum.*

There seem to be no real differences in the nitrogen content of the species listed, with the exception of *G. triphyllum* which seems to have a significantly higher protein content than the rest.

The lysine data are for the free ε-amino groups of lysine in the seed proteins. From the data it does not appear that there is any difference between species in the lysine content of the proteins.

In all instances where the data are adequate, the curves obtained on plotting the specific absorptivity (Table II) for the oils from the different species against the wave length show a maximum in the range of 360-380 millimicrons, a shoulder in the range 260-270 millimicrons, and a maximum in the range 220-230 millimicrons. Although gossypol is only slightly soluble in petroleum ether, it may be expected that gossypol will be found in the solvent extracts of the gossypol-

TABLE II
SPECIFIC ABSORPTIVITIES OF OILS OBTAINED FROM *Gossypium* SPECIES

| Species | Wave length in millimicrons[a] | | |
|---|---|---|---|
| | 220-230 | 260-270 | 368-380 |
| *G. arboreum* | m. 1.40 | sh. 0.68 | m. 0.16 |
| *G. anomalum* | m. 1.25 | m. 0.17 | ..... |
| *G. triphyllum* | ..... | sh. 0.07 | ..... |
| *G. stocksii* | m. 1.42 | m. 0.17 | ..... |
| *G. aridum* | m. 0.94 | sh. 0.21 | m. 0.04 |
| *G. armourianum* | m. 1.25 | sh. 0.60 | m. 0.17 |
| *G. harknessii* | m. 4.92 | sh. 0.80 | m. 0.14 |
| *G. klotzschianium var. davidsonii* | m. 2.64 | ..... | m. 0.43 |
| *G. raimondii* | m. 1.20 | sh. 0.40 | m. 0.09 |
| *G. thurberi* | m. 1.59 | m. 0.16 | ..... |
| *G. hirsutum*, commercial variety | | | |
| Deltapine 15 | m. 1.05 | sh. 0.31 | m. 0.09 |

[a]m. indicates absorption at maximum and sh. at shoulder on absorption curve.

containing seeds. Apparently the absorption maximum noted for the oils at 360-380 millimicrons and the shoulder noted at 260-270 millimicrons may both be attributed to gossypol, since gossypol shows absorption maxima at these two wave length bands.

## Summary

Marked differences were observed in the gossypol contents of the kernels of species of *Gossypium* studied. The values ranged from 0.13 to 6.64 percent. No such differences were found in the lysine content of the protein expressed as grams per 16 grams of nitrogen.

## Acknowledgment

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# Historical and Ethnobotanical Aspects of Domestication in Tagetes[1]

LAWRENCE KAPLAN[2]

It is generally accepted that the genus *Tagetes* is native to the New World. It is also accepted, albeit implicitly, that the principal cultivars of the genus, *Tagetes erecta,* L. Sp. Pl. 887, and *Tagetes patula,* L. Sp. Pl. 887, reported to have 24 and 48 somatic chromosomes, respectively (2), were domesticated in the New World in pre-Columbian times. *T. erecta* and *T. patula* appear in the 16th century herbals with Fuchs' (3) figure and description of *Tagetes indica,* a pre-Linnean name for *T. patula,* the French marigold. *T. erecta,* the African marigold, appears probably for the first time in 1576, in the Plantarum of Lobel (4) as *Othona maior polyanthos* and *Flos africanus maior simplici.* Fuchs placed his *Indianische negelen* or *Tagetes indica* with his artemisias because of their common, pungent odor. The name *Tagetes* was said by Fuchs to be the original form of which *tanacetu* was a corruption and, since tanacetu was a common name for his *artemisia monoklonos* (*Chrysanthemum tannacetum* Karsch.) and his *Indianische negelen* was considered similar to this, Fuchs first applied the name Tagetes which was later adopted by Linneaus. There appears to be little evidence to support the frequent assertion that "Tagetes" is derived from "Tages," the name of an Etruscan god.

The use of *Tagetes indica* by Fuchs, and *Garyophillis indicis* by Bock (1) in 1550 clearly points to the then current concept of India as the place of origin of *T. patula,* while the use of *Flos africanus,* beginning with Lobel in 1581, must indicate North Africa as the presumed place of origin of *T. erecta.* Bock's reference to *Garyophillis indicis* is clearly to *T. patula* and he states that this plant came to Germany in the time of Charles V. Lobel in 1576 figured *T. patula* and both single and double *T. erecta* and stated that marigolds grew spontaneously on the stony banks of the Tagum, a river of Portugal and central Spain.

Sahagun (6), sometime between 1547 and 1577,[3] referred to marigolds in New Spain, using the Nahuatl name, *Cempoalxochitl,* both as double and single yellow flowered plants of good odor, some of which were volunteers (*se nacen*) while others were planted in the gardens (*huertos*). His judgment of the odor of marigolds was distinctly at variance with that of the European herbalists.

The importance of marigolds in certain religious celebrations in northern India is well known, and Watt (6) in 1893 indicated the coincidence of the ceremonial use of marigolds with areas of Portuguese influence in western India. Thus, phytogeographic observations and pre-Linnaean nomenclature point to Iberia or the Mediterranean or East Indian areas of Spanish and Portuguese influence as the routes by which domesticated marigolds entered Europe. Since the herbalists almost always omit *Tagetes* species from discussions of medicinal plants and sometimes include them among noxious or

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[2]Department of Biology, Roosevelt University, Chicago, Illinois.

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[3]1547 marks the approximate date of the beginning of the studies of Sahagun, and 1577, the date of translation from Nahuatl to Spanish, according to Garribay (6), Vol. 1, p. 13.

poisonous plants, the rapid diffusion of marigolds throughout Europe and South Asia can only be explained by their having been well-developed ornamentals prior to their introduction to the Old World.

Throughout Mexico and Guatemala at the present time marigolds are the flowers most used and most appropriate in ceremonies for the dead. The fact that this use has pre-Columbian origins is borne out by the depiction of small maize ears alternated with large marigold inflorescences in a garland about the neck of a figure on a pre-Conquest funeral urn from the Valley of Mexico. The marigold heads on this figure in the Museo Nacional in Mexico, D. F., consist entirely of flat, ligulate ray flowers and are 5 cm. in diameter. Their form suggests *T. patula* rather than *T. erecta* and their size and doubleness, even if the original models were not quite so perfect, indicate a concept of perfection which could only be correlated with selection practices. There is no evidence that *T. patula* or *T. erecta* exist outside of cultivation or semi-cultivation at the present time unless they are naturalized, having escaped from cultivation.

In Guatemala and Mexico the most common Spanish name for marigolds of both species is Flor de Muerto, a name which reflects their customary use in connection with All Saints Day, November 1, and, more especially, with All Souls Day (*dia de los muertos*), November 2. These celebrations are part of the Catholic religious calendar but are in part syncretic with indigenous religion and the use of the marigold is clearly a pre-Columbian retention.

Marigolds in Mexico begin to bloom in August and September and reach their greatest abundance at all elevations in October and November. In Indian communities, the blossoms are cut at the end of September and are tied into bundles and fastened, often with other flowers and leaves, to arcs which are used to decorate the household altars. Among the Low Mixtecs on the Pacific Coast of Oaxaca, the ligulate florets are plucked from the heads the day before All Souls Day and are distributed along the pathways leading to the houses in order to guide the souls of deceased children to the altars on which are placed food and other offerings. The florets and inflorescences are also used at this time to decorate graves, as a result of which it is not uncommon to find marigolds as apparent volunteers in cemeteries. For the strewing of pathways and grave decoration, the selective value of the double flowering character is evident. Bunches of selected double flowered marigolds drying in the eaves of houses for the following year's seed are familiar sights from November through the dry season. Drying of selected bunches of marigolds has also been observed in the *tierra caliente* of the Central Depression of Chiapas. In both of these areas and, it might be inferred, in other hot country areas where herbaceous plantings in house gardens are not emphasized, the achenes derived from the curing bunches are carefully saved, and planted in the *milpas*, which are often at some distance from the villages.

In the Chiapas highlands the house gardens are actually small cornfields adjacent to the houses and in these plots marigolds grow as apparent volunteers between the corn rows or at the edges of trash heaps. In the highlands, the use of the hoe or mattock permits selective weeding in contrast to the machete, which is used in the lowlands. Marigolds, *Physalis* sp., and occasionally other useful species are allowed to remain when weeds are cut out of the highland gardens, and it is claimed by some Indians that it is possible to distinguish between marigold seedlings which will bear double heads and those which will bear single heads. This is probably a distinction between the ridged green stems of *T. erecta*

and the nonridged rose-tinted stems of *T. patula*. Although genetic control is probably similar (2), doubling appears to be more frequent in *T. erecta* than in *T. patula*. In weeding, the suspected single bearing seedlings are removed while the potential doubles are permitted to remain and are encouraged by the cultivation which is primarily intended to improve corn growth. As single inflorescences appear they may be pulled out or they may simply be left in the field when the doubled inflorescences are cut for the altars. Of course, if there is a shortage of the more desirable double heads, the singles are used. If the field-garden is burned during the dry season, any fallen achenes of the single heads are likely to be killed.

The blossoms used for arcs and other altar decorations remain in place until they dry and the fragments fall. Since the achenes of ripe, well-dried marigold inflorescences fall or are easily dislodged from the heads, large numbers of them drop to the floors of the houses. These, along with other household debris, are swept periodically and the trash is discarded in dooryard heaps or in the household *milpa*. In some cases, a limited concept of fertilization of the soil, by throwing household sweepings into the gardens, appears to exist. However, unless elicited by direct and intensive questioning, there is no conscious realization that discarding household trash constitutes the reseeding of marigolds and, moreover, the reseeding of selected strains.

This pattern of selection of desirable phenotypes for religious purposes, followed by propagation of these selected strains by very commonplace activities, is suggested as the means by which marigolds were first domesticated and later diversified. Domestication of marigolds, then, probably took place many times within the highland part of the natural range of the wild plants and an interaction between the genetic potentiality of the plants and human ideas of perfection set the pattern of variation.

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# The South American "Sapote"

W. H. HODGE[1]

The name "sapote" (sometimes spelled "zapote") is most commonly and correctly associated with species of the Central American genus *Calocarpum*, particularly *Calocarpum sapota* (Jacq.) Merr., one of the best known and widely cultivated of the sapotaceous (*Sapotaceae*) fruits of the American tropics.

In northwestern South America (Colombia to Peru), there occurs a quite unrelated tropical tree, *Quararibea cordata*, whose fruit also passes under the name of sapote, probably because of the similar form of the fruits of the two species. To obviate confusion, the fruit of *Quararibea cordata* might better be called "South American Sapote." Outside the region of its natural growth and culture, this tree is little known and since but little descriptive material occurs in the literature, it seems worthwhile to present a short descriptive account.

Belonging to the family *Bombacaceae*, along with such economically important genera as *Ceiba* (kapok) and *Ochroma* (balsa), *Quararibea* is, to my knowledge, the only New World genus of the family producing an edible fruit. In quality the South American Sapote scarcely can compare in flavor or popularity with the Old World durian (*Durio*), the best known bombacaceous fruit.

Most references to the South American sapote as a fruit-producing tree place it in the genus *Matisia* under the species *M. cordata* H. & B., which is the type species. Recent taxonomic opinion assigns *Matisia* to synonymy under the genus *Quararibea*, the combination *Quararibea cordata* (H. & B.) Garcia-Barriga & Hernandez having been made in 1952 (1).

*Quararibea cordata* appears to be native primarily to lowland areas in northwestern South America—on the littoral, in warm intermont valleys, and in the drainage system of Amazon tributaries close to the Andes. Williams (3) describes this species from Loreto, Peru, as a lowland forest tree ". . . attaining a height of 45 to 100 feet. Crown round or flat, trunk erect, cylindrical, up to 26" above the large buttresses, and clear of branches for from 1/3 to 3/4 the entire height." It appears that lowland rain forest areas represent the original home of the species and that it may have been carried and planted by man as a dooryard tree elsewhere, particularly at higher elevations in the northern ranges of the Andes. Popenoe (2) describes the species as one of the commonest fruit trees of the Ecuadorian lowlands (littoral) "but cultivated up to elevations of about 1200 meters." Under cultivation, he says, it reaches an ultimate height of about 12 meters. This is confirmed by my own observations of tree height in northern Peru (Department of Cajamarca) and in central Colombia (Department of Antioquia). At Medellín, Colombia, a specimen flourished in my backyard at an elevation of slightly over 5000 feet (Fig. 1).

As usually seen in cultivation *Quararibea cordata* is a medium tree of upright habit with verticillate stiff branches bearing large (15-30 cm. long), cordate, glabrous, coarse-veined, terminally-clustered leaves. The 5-parted, cream-colored flowers appear abundantly in irregular clusters along the smaller branches (Fig. 2). Whether there is a regular season

[1]Department of Education and Research, Longwood Gardens, Kennett Square, Pennsylvania.

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Fig. 1. Whorled branches of *Quararibea cordata* with fruits and foliage. Tree cultivated at 5000 feet elevation, Medellín, Colombia.

Fig. 2. Clustered cauliflorous flowers of the South American Sapote. Western drainage of Alto Marañon, Department of Cajamarca, Peru.

for flowering is unknown though it is likely that this depends upon local geographical conditions. Flowers have been observed by me in late July in northern Peru and in February at Medellín, Colombia, locations equidistant from the Equator. Fruits matured at Medellín, eight months after flowering. Fruits are the size of a large pear, are elliptical in shape and mammillate at the blossom end. The thick leathery skin is pubescent and brownish-green in color. A heavy woody stalk joins the fruit to the branch.

At the time of maturity growth brings a bit of the fruit's surface from out under the protection of the heavy, persistent calyx, producing a readily visible ring of lighter tissue, an indication that the sapote is ready for picking. An opened ripe fruit reveals a fibrous orange-yellow flesh in which are embedded two to five seeds (Fig. 3). Fruits of the South American Sapote are sweet flavored and apparently always eaten out-of-hand. They are apparently widely relished in their areas of production, particularly by country folk. Some people, however, consider them a little too fibrous. In Popenoe's opinion (2) this sapote "cannot be considered a fruit of great value." Having been a frequent eater of these fruits during a sojourn in Colombia, I can agree with him.

*Quararibea cordata* has apparently not been transported widely in the tropics outside of its natural range. It is undoubtedly tender and would probably not thrive in subtropical areas like southern Florida. In its area of cultivation no se-

Fig. 3. Mature fruits of *Quararibea cordata* showing lighter ring of tissue fringing the leathery calyx (left) and fibrous edible pulp. Medellín, Colombia.

lection of superior strains appears to have been made and all trees in culture are evidently seedlings.

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# Grape Growing in Greece

ROBERT J. WEAVER[1, 2]

## Introduction

The culture of the grape and its accompanying art of wine making are of great antiquity in Greece. According to De Candolle (3), use of the grape doubtless began in prehistoric times. The poet Homer mentioned grapes and wine, and the art was probably known much earlier. The ancient Greek god, Dionysus, was patron of the crop. The Romans probably gained their knowledge of grape growing and wine making from the Greeks, and for a long time they much preferred Grecian wines. It was the Greeks who founded French viticulture, near Marseille. Greece has long been famous for its production of the currants of commerce, from the 'Black Corinth' (or 'Zante currant'). According to Eisen (9), Pliny mentioned currants in the year 75 A.D. In herbals of the eleventh century and in literature of the fourteenth through sixteenth centuries, currants are referred to as "reysyns de corauntz," "corauntz," "corent," "corawnce," "raysns of coren," and currans." Raisins probably reached England as early as the thirteenth century (2). The species grown by the ancient Greeks, *Vitis vinifera* L., is still the one used in modern viticulture. This species is referred to as the Old World or European grape.

Greece, including its islands, totals about 51,161 square miles (32,743,040 acres). Cultivated acreage is listed as 8,905,585 acres, about 27.2 per cent of the total. About 6.3 per cent of the total cultivated area (some 557,870 acres) of the country is devoted to grapes which presently rank second only to tobacco as the most important export crop (about 23 per cent of the total value of crop exports).

[1]Department of Viticulture and Enology, University of California, Davis, California.

[2]Formerly Senior Fulbright Research Scholar, Superior College of Agriculture, Athens, Greece.

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## Geographic Distribution and Climate

Grapes are widely distributed throughout Greece (Fig. 1). The greatest concentrations, however, are in the counties of Attica, Argolis-Corinthia, Achaia, Elia, and Messinia, and on the island of Crete (Table 1).

Lowland Greece has a Mediterranean type of climate, characterized by long, hot summers and mild, rainy winters. The uplands are cooler and rainier. The west coast has the most precipitation, averaging 30-40 inches per year, and the mildest winters. Eastern Greece generally has 20-30 inches of annual precipitation, and very dry, hot summers. The coldest winters are in the northwest, where rainfall also occurs in the summer.

## Cultural Practices

**Establishment of vineyard and spacing.** Near Salonica, I observed a new vineyard being laid out in a chalky soil according to the method prescribed by the American Farm School at Salonica. 'Rhazaki' scions had been grafted onto '99R' cuttings. Holes were made about 6 feet apart (about 1200 vines per acre) with an iron-foot punch. After the rooting (from which all roots were cut off) had been placed in the hole, it was filled with water, and about 1 hour later was covered with soil. The grower paid about 10 cents per grafted rooting; ungrafted rootings were available at one cent each.

As in other parts of Europe, vines are closely planted in Greece. One commonly

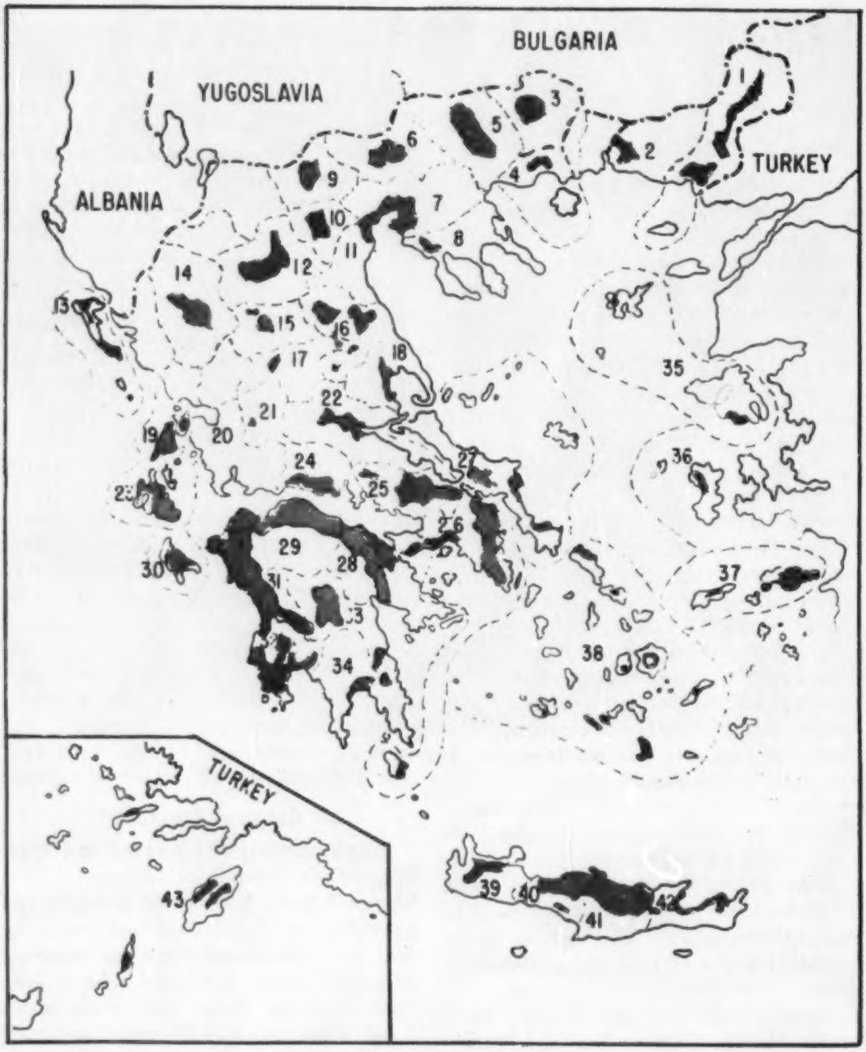


Fig. 1. Locations of the major grape-growing regions of Greece. The county (nomoi) boundaries are the broken lines, and each county producing grapes is numbered. Adapted from map prepared by American Mission for Aid to Greece, February 12, 1948.

finds 1000-2000 vines per acre, in contrast to 400-600 vines per acre in California. Most vineyards in phylloxera-free areas, especially those on hillsides, are not planted in rows. Rows often gradually disappear from vineyards as new vines are propagated more or less at random from layers from a mother vine. When a vine is nearly dead, a layer is often made, and the old vine removed

TABLE I

MAP INDEX AND AREA OF VINEYARDS IN THE VARIOUS COUNTIES (NOMOI)

| County (Nomos) | Number on Map | Areas in Acres |
|---|---|---|
| Achaia | 29 | 43,700 |
| Aetoloacarnania | 20 | 6,100 |
| Arcadia | 33 | 15,750 |
| Argolis-Corinthia | 28 | 42,525 |
| Attica | 26 | 58,060 |
| Boeotia | 25 | 21,350 |
| Cephalonia | 23 | 7,800 |
| Chania | 39 | 14,100 |
| Chios | 36 | 1,800 |
| Cyclades | 38 | 14,100 |
| Dodecanese | 43 | 6,200 |
| Drama | 3 | 3,500 |
| Elia | 31 | 50,180 |
| Emathia | 10 | 2,900 |
| Euboea | 27 | 9,450 |
| Eurytania | 21 | 260 |
| Evros | 1 | 5,050 |
| Heraklion | 41 | 35,600 |
| Ioannina | 14 | 5,900 |
| Kardhitsa | 17 | 2,750 |
| Kavala | 4 | 3,425 |
| Kerkyra | 13 | 11,300 |
| Khalkidhiki | 8 | 5,325 |
| Kilkis | 6 | 5,475 |
| Kozani | 12 | 11,175 |
| Laconia | 34 | 7,600 |
| Larissa | 16 | 8,575 |
| Lassithiou | 42 | 7,600 |
| Lesvos | 35 | 3,875 |
| Magnissia | 18 | 4,850 |
| Messinia | 32 | 57,285 |
| Pella | 9 | 3,770 |
| Phokis | 24 | 7,550 |
| Pieria | 11 | 1,950 |
| Preveza | 19 | 410 |
| Pthiotis | 22 | 10,150 |
| Rethymnon | 40 | 8,975 |
| Rhodope | 2 | 2,685 |
| Samos | 37 | 4,650 |
| Serrae | 5 | 9,900 |
| Thessalonike | 7 | 13,650 |
| Trikkala | 15 | 1,900 |
| Zante | 30 | 8,500 |
| All others | | 10,220 |
| Total | | 557,870 |

Source: Greek Ministry of Agriculture and Agricultural Bank of Greece. Data for 1957.

after the new plant gets a start. In recent years newly planted vineyards on American rootstocks have been laid out in rows. The close, and often irregular, spacing of vines prevalent in Greece does not permit mechanical cultivation and spraying, which would reduce labor costs. (Fig. 2). Most vineyards in Greece are regular plantings, *i.e.*, they are not interplanted with other species. In some locations, however, olive, fig, or other species are interspersed.

**Training.** Training refers to developing and directing the growth of young vines by pruning and disbudding, and by the use of stakes or trellises to maintain the vine in the desired position. The head, or goblet, system is most commonly used in Greece. In some varieties there is no trunk, the head rising directly from the soil surface, as in the 'Savatiano' vines in Attica in which the bases of spurs of young vines are right at the soil surface. Such a vineyard after winter pruning appears to be a barren field unless it is closely inspected. When vines are 40-50 years old, however, their trunks may attain heights of 8-12 inches (Fig. 3). It is believed that low training prevents the breakage of shoots in Attica and other regions of high winds. Low training is supposed to advance maturation in upland areas such as Tripolis, and reduce loss of soil moisture in dry lowlands. In other cases trunks are 2-3 feet tall.

In a few instances wire trellises are used (Fig. 4). The arms of head-trained vines are tied to stakes in the winter so they can bear the weight of fruit the following growing season. The stakes used are of various types, but one commonly used is Giant Reed or Arundo (*Arundo donax* L.) Most growers produce their own supply of these stakes in or at the edge of their vineyards.

Overhead arbors are used for 'Rhazaki' (syn. 'Dattier') and 'Sideritis' table grapes. In the Rhazaki area of Crete, arbors are about 5 to 6 feet in height. Chestnut, olive, or reinforced concrete stakes are used to support these arbors. Wires or stakes are placed over the arbors to form squares of about 15 inches. Arbors cost $800-$1000 per acre. Reinforced concrete stakes weighing 70 pounds cost 75 cents, but since these tend

Fig. 2. 'Black Corinth' vineyard near Kalamata in Messinia. These closely planted vines have long arms and are spindly in this region. Note cactus fence, a type surrounding many vineyards in the area, and often growing ten feet tall. The cactus fruit is used to make sweets and feed hogs.

to crack, iron stakes, which cost about the same, are preferred.

An interesting and unusual training operation is performed in the Nemea basin in the Peloponnesus on the variety 'Nemea mavroudi,' which is headed low to the ground. In early June the sprawling shoots are gathered together and tied into a simple knot (Fig. 5). In the process, shoots are often cracked. There are about 5,000 acres of this variety. According to growers, this practice gives larger berries and easier harvest. The same training practice exists in the Zitsa district of Epiros (northwestern Greece) for the wine grape 'Debina' and for other wine grapes in the Ionian islands. Growers say such training prevents *coulure* (excessive berry shatter following flowering) and protects the fruit from hail damage. Further advantages claimed are a reduction in transpiring surface, improved air circulation around the fruit, and facilitation of cultural operations.

In some islands of the Cyclades, where grapes are grown near the seacoast, a basket system of training is used for certain wine grapes such as 'Asyrtico.' Vines are trained low to the ground, and 3 to 5 canes are brought together at the end, forming a crown. According to Davides (5, 6) this system protects the fruit and part of vegetative growth from strong winds and salty spray.

**Pruning**. Pruning consists of removing canes, shoots, leaves, and other vegetative parts of the vine. Dormant pruning is usually performed in winter, when there is no foliage. Spurs are the basal portions of canes, from 1 to 4 buds long. Wine grapes are usually trained to 3 or 4 arms and spur-pruned to one or two

Fig. 3. 'Savatiano' vineyard in the Mesoyea on the Attica peninsula. The trunks on these 40-50-year-old vines are only 6-8 inches in height.

buds, although there is some variation in this practice. With 'Black Corinth,' a raisin grape, the number of arms may vary from 8 to 12, and each arm has a spur with one to three buds. In Corinth, 'Sultanina' (syn. 'Thompson Seedless') is pruned to 3 to 5 arms, each bearing a half-long cane with 5-6 buds per cane; in the calcareous soils of Crete, however, these vines usually bear about eight arms, each with a spur of 4 buds. Canes are supported in a horizontal position by staking. In California, 'Sultanina' is pruned to long canes (twelve or more buds) and the canes tied to trellis wires. 'Black Corinth' in California is usually also cane-pruned on trellises. Staking allows the use of half-long or long canes, eliminating a need for wire trellis. Canes must be held horizontal to ensure that many buds grow. On vertical canes, only the apical two or three buds produce shoots.

The 'Rhazaki' near Heraklion, Crete, is head-trained and usually has 5 or 6 arms, each bearing a half-long cane of 6 to 7 buds. The system of pruning varies in other localities. 'Sideritis,' grown mainly in the district of Aeghion and Patras, is head-pruned to 5 or 6 arms, each bearing a spur usually 3 buds long. Near Corinth, 'Fraoula' is head-trained with many large arms, each bearing a spur of 3 or 4 buds or two spurs of 2 buds each. Grape prunings provide part of the firewood required by the grower. Grape canes make the best firewood for roasting, and for this reason there is much pruning before Easter, when Greeks roast lambs on spits. Double pruning to delay shoot growth in spring is performed only in cases of labor scarcity.

Fig. 4. 'Rhazaki' vines pruned to 5 or 6 canes each 7-10 buds long. Canes are tied to the lower wire of a 2-wire trellis. This type of training is similar to that used in California for 'Thompson Seedless' for raisins. About 8 miles south of Salonica.

Several pruning tools are used in Greece. The *cladeftheri* is commonly used in the Peloponnesus. Skilled pruners prefer it to pruning shears, for they say the wood to be cut may be reached more easily. This tool has a sharp curved blade, and a chopping surface for large canes. Saws are also carried. In Attica and Crete the *svanas* is usually used. This saw-like tool is called a *tertsete* in Crete. In northern Greece and the Kalamata region, pruning shears are used.

Summer pruning (removal of green vegetative portions of the vine) is widely practiced in Greece (5). Topping is the removal of a foot or more of the shoot tip, and is practiced on 'Sultanina' and some wine grapes subject to coulure. 'Black Corinth,' an exception, is not topped or pinched. Ordinarily, shoots are first topped from 1 to 4 nodes above the apical flower cluster when they are about 1½ feet long. 'Sultanina' is topped severely—just above the apical cluster. This practice is often repeated 3 to 6 times until late July. According to Davides (5), the practice is useful only when soil water is low for it cuts down the transpiring surface. Numerous growers, especially of 'Sultanina,' told the author they expected larger berries and clusters and a large second crop from topping. There is little doubt that harvesting and other field operations are facilitated by topping in Greece as well as in other European countries where

Fig. 5. Tying of the tops of 'Nemea mavroudi' vines into a simple knot. The vines are referred to as "little bears." This practice is performed after the set of berries in June. Vineyard near Nemea. (Photographed June 7, 1956.)

vines are closely planted. Work in California, however, has demonstrated that summer pruning is a weakening operation. Topping is done by women who can often work over an acre per day.

Another type of summer pruning consists of removing leaves around and below the clusters in raisin and table grapes. Leaf removal is performed in 'Black Corinth' and 'Sultanina' about one week after girdling, and is sometimes repeated in August to enhance maturation and harvesting. With raisin grapes this practice is probably of little value. With 'Sideritis,' leaf removal is done during the ripening period to facilitate maturation. With 'Rhazaki' it is performed before ripening begins, to avoid injuring the clusters with vegetative growth, and it is repeated late in the season to aid maturation. In Corinthia, head-trained vines of 'Rhazaki' and 'Fraoula' are subjected to leaf removal when clusters are young, a heritage of the past used for control of berry moth and powdery mildew when chemical methods were unavailable. An additional form of summer pruning occurs after harvest, when some vineyards are sheeped. This practice of allowing sheep to eat the foliage weakens the vines, and canes and arms are frequently broken when the wool of the sheep becomes entangled in the vine. Sheeping the vineyard is common in the Peloponnesus. It should be mentioned that no thinning (removal of unripe fruit) is practiced in Greece.

**Girdling**. Girdling, also called "ringing," as practiced in California, is the removal of a complete ring of bark ⅛-¼ inch wide from the trunk or from an arm or a cane below the fruit it is intended to affect. As a result, the carbohydrate materials produced in the leaves will accumulate in the parts above the wound, including the clusters of blossoms or fruit, and will materially influence their development. The wound usually heals over within 3 to 4 weeks. In Greece, this type of girdling is usually performed on the trunk and referred to as double girdling. In other instances, a simple incision (no ring of bark removed) is made with girdling pliers at the base of the shoots or on the spurs. Injury to the vine is much less likely in the nonirrigated vineyards of Greece when the simple incision is made, since such wounds heal over rapidly. The double girdle may fail to heal, killing all parts above the girdle. It is believed that girdling was discovered in Zante island in 1833, when it was observed that berry size increased greatly on a 'Black Corinth' vine whose bark had been worn off by a rope attached to a burro. The practice passed to Elia by 1848 and since then has been used in all the Peloponnesus (Davides, private communication). Before the advent of

girdling, the crops of 'Black Corinth' were no doubt much smaller than at present.

'Black Corinth' is girdled while the grapes are in bloom or shortly thereafter. In the Vostizza, the region producing the highest-quality currants, girdling is delayed until shortly after bloom. In Messinia, where high production is of greatest importance, vines are girdled during bloom. Girdling at bloom results in the setting of the greatest number of berries. In all instances, girdles must be made before the shatter of too many berries, or the crop will be small. Without girdling, small straggly clusters of tiny seedless berries are produced. The growth regulator 4-chlorophenoxyacetic acid (4-CPA), which has completely replaced the girdling of 'Black Corinth' in California, has also been used in Greece. For example, in 1956 about 15,000 acres were sprayed, and in 1959 about 75 lbs. of 4-CPA were used for this purpose. Experiment is also under way on using sprays of gibberellin to induce set. Sprays of plant regulator are applied during or immediately after the bloom period. 'Sultanina' vines used for table grapes in the Corinth region are girdled following the shatter of berries after bloom, a practice also followed in California to produce larger berry size. In Crete, girdling is practiced on 'Thompson Seedless' where berry size is small (5).

**Cultivation and Irrigation.** Most cultivation in Greece is performed by hand labor. After the fall rains, basins are dug around the vines with *tsappas* or *axines*. The latter is the heavier trenching tool used to cultivate heavier soils. The basins, usually 4 or 5 inches deep and the same diameter as the head of the

Fig. 6. Flat cultivation in a 'Sultanina' vineyard near Peza, Crete. The author used this vineyard for experimental work. Note absence of trunk, and that basins are still around the vines. In the background are concrete stakes used to make arbor supports in a Rhazaki vineyard.

vine, catch rain water, and fertilizer may be placed therein. Weeds are killed in a spring clean-up for which three types of cultivation are used. In some areas (Crete) the soil is left flat (Fig. 6). In others (Attica) furrows are made. Plows may be used in the flat lands of the Mesoyea, in Attica. The third method is to pile soil into mounds between the vines (Fig. 7). One or two piles are ordinarily made. The piles are leveled off in April or May, killing the new crop of weeds. Growers believe this method of plowing has the added benefit of increasing aeration, and rendering more nutrients available to the vine. Such benefits have not been demonstrated by experimental work, however. During the spring clean-up it is common to see 15-20 laborers plowing the land under the supervision of a foreman. Some moto-cultivators are now appearing, but work around the vines must still be done by hand. Close planting discourages the use of mechanical cultivators, and nothing but hand labor is feasible on some steep mountainsides where vineyards reach right up to the sheer rock of the mountain. Few vineyards in Greece are irrigated, though there are some exceptions.

### Harvesting and Drying of Raisin Grapes

Raisin grapes are picked with scissors, put in baskets, and taken to flat open surfaces called *alonia* (Fig. 8). Most alonia are made by wetting a clay surface to produce a hard, baked surface (Fig. 8). In some cases the clusters are laid on a special paper to dry, and in other cases there are cement alonia. Sometimes the clusters are placed on trays with wooden or wire-mesh bottoms called tzivieres, which are placed on the alonia (Fig. 9). The trays are about 5 feet 3 inches by 2 feet 7 inches. Alonia are about 12 x

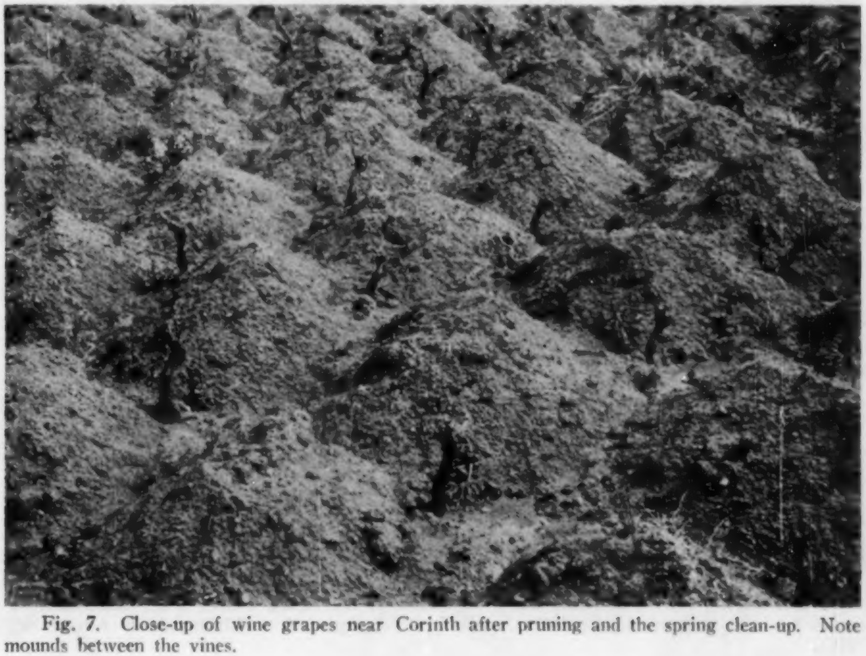

Fig. 7. Close-up of wine grapes near Corinth after pruning and the spring clean-up. Note mounds between the vines.

90 feet and can hold around 600 lbs. of dried grapes. The drying of currants ('Black Corinth') may take 7-12 days, and the clusters are usually turned over once. An aloni is used several consecutive times in the harvest season. There are stakes down the middle of the aloni so that tarpaulins can be attached to protect grapes from rains or heavy dews. Only 2 or 3 minutes are required to put up a tarpaulin. In many locations there are 30 or more alonia in one open area.

Higher-quality raisins are produced by drying in the shade. This method is commonly used in Corinthia and Achaia. The drying sheds are constructed of wood or iron poles and the roof is of corrugated tin sheeting. In some sheds trays are used for the grapes, and in others wires are stretched lengthwise on which clusters may be hung. There are several "floors" of wire in each shed. Drying in the shade may require 20-30 days. Sheds are so constructed that canvas sides can be hung in case of rain. Another method of drying in shade is to stack the trays. For the finest currants, the clusters are hung on the shoots of the vine, to dry in the shade of the foliage (Fig. 10). This method cannot be used where there is heavy wind or rain during the drying period. Since an unexpected rain can ruin the whole crop, this method of drying has almost completely disappeared. Many berries were lost on the ground with this method.

In Greece the vineyardists live in villages and travel to the vineyards daily. During harvesting and raisin drying, however, the growers live in the vineyards. In the mountainous Vostizza area, where the highest-quality currants are produced, the countryside is dotted

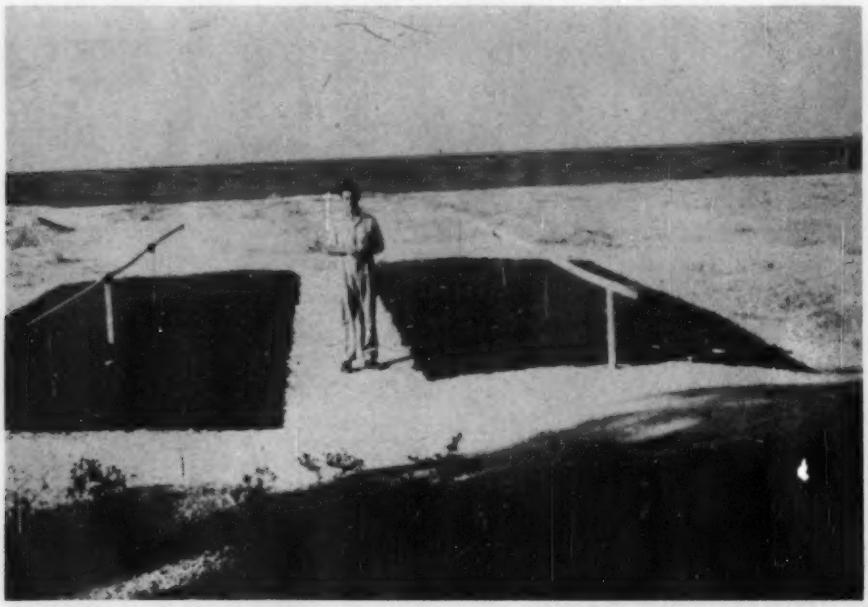

Fig. 8. 'Black Corinth' grapes drying on alonia made of clay near Xylocastron on northern shore of Peloponnesus. The board along the center of the drying grapes is for attachment of canvas for rain protection. Gulf of Corinth is in background. (Photographed August 13, 1956).

with drying sheds, alonia, and adjacent summer homes.

### Labor

Nearly all cultivation, spraying, dusting, etc., is done by hand. Mountainous terrain, close and irregular vine spacing, lack of trunks in many vineyards, small and scattered holdings, and other factors prevent mechanization at present. Labor was plentiful and cheap, but the cost has recently begun to climb. Sooner or later the industry will be forced to mechanize to reduce labor costs. One factor compelling hand labor is the low training in many vineyards. Where no trunk exists, hand cultivation is even more difficult. Still another factor discouraging the use of mechanized equipment is the small holdings and the fragmentation of vineyards. Growers may own small blocks of vineyard in various locations. Thus, 3 or 4 acres may comprise several plots —in certain instances as many as fifty (8). It is not uncommon for a grower to have to walk 2 or 3 hours to get from one piece of his property to another. As an example during the selection of vineyards for experimentation in the Vostizza, I rode a donkey from a village in the Vostizza for 30 or 40 minutes up steep slopes, with the grower, to a vineyard property of only one-fourth acre (one stremma). Small holdings are very common, though some are in the range of 2-10 acres. Greek inheritance and dowry laws tend to disperse property. Furthermore, present Greek law limits farm size to a maximum of 75 cultivable acres.

Two or three examples will serve to show the price for labor in 1956. Girdling or harvesting near Kalamata paid $2.70 per day plus food and wine. The food

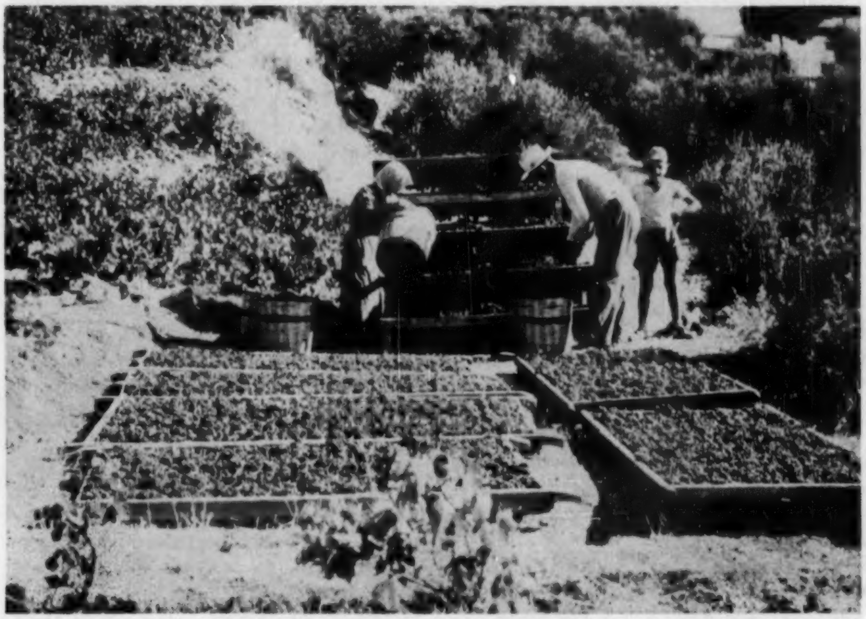

Fig. 9. Hanging 'Black Corinth' grape clusters on tzivieres near Platanos in Achaia. The tzivieres are stacked one upon the other so the grapes can dry in the shade. (Photographed August 13, 1956).

Fig. 10. Vine with clusters drying on branches. Leaves have been removed to expose clusters. Near Platanos. (Photographed August 13, 1956).

and wine cost the grower about 70 cents. Cultivators near Peza, Crete, received the same wages, though the prevailing wage in most places in Crete was $1.85 plus meals and wine. These wages, while low by American standards, represent a sharp increase in Greece. Groups of cultivators always had jugs of retsina (resin wine) on hand during their labors, and, showing a friendliness typical of the Greeks, always insisted that any passerby have a drink.

### Diseases and Insects

Only some of the most important diseases and insects are discussed here. The downy mildew (*Plasmopora viticola* B. & C.) one of the major diseases, is controlled by spraying with Bordeaux mixture 2 to 15 times a year. Cement containers for mixing the Bordeaux are a common sight along the Corinth to Patras highway. Application is by hand sprayer. The downy mildew, fortunately, does not occur in California, where the growing season is too dry. Powdery mildew (*Uncinula necator* Schw.) is widespread, and is prevented by dusting with sulphur several times during the season. Burlap bags and hand dusters are used. These methods have the disadvantage of getting too much sulphur on parts of the leaves, which results in leaf burn when temperatures are high. Mechanical blowers used in California produce a fine cloud of dust that envelops the whole vine.

The root louse, phylloxera (*Dactylosphaera vitifoliae* Shimer), has been in northern Greece and Thessaly for many years. All possible steps are being taken by the Greek government to prevent its rapid spread to the south. The only control for phylloxera is the use of resistant rootstock. Most grapes in northern Greece are on rootstocks, and studies are

being made by the Greek government to determine best stocks for other parts of Greece in case the phylloxera spreads widely. The author was told that there was much spread of phylloxera in World War II and some is now in Attica as a result. According to Davides (7), 'R 110,' '41 B,' '5 BB,' 'R 99,' '420 A,' and 'St. George' are some of the most suitable stocks for northern Greece. Virus diseases are also widespread in Greece (13).

### Varieties

Greek grapes may be classified into three groups by use: table, raisin, and wine grapes. Table grapes are used fresh for food or decoration, raisin grapes are those that produce an acceptable dried product, while wine grapes have been defined as varieties known to be capable of producing an acceptable wine in some locality. The grape varieties of major importance, their chief locations, and total acreages are shown in Table 2. The two leading raisin grapes, 'Black Corinth' and 'Sultanina' (syn. 'Thompson Seedless'), occupy 145,517 acres of the total 557,870 acres of vineyard. A small amount of these varieties is also used for local table use. The two main table grapes, 'Rhazaki' and 'Sideritis,' occupy about 16,511 acres. In addition, a large area is made up of small acreages of a large number of varieties. Wine grapes occupy 372,793 acres. Thus Greece, although less than one-third the area of California, has a greater area under grape cultivation.

**Table Grapes.**[1] *'Rhazaki' ('Dattier')*, the leading table grape, is grown in many grape-growing districts (4, 7). The largest acreage of grapes is located south of Heraklion, Crete, near Archana (Fig. 11). 'Rhazaki' is sometimes grown on

[1] In description of varieties, much use was made of the Report by U. X. Davides (6) to the VIII Congrès International de la vigne et du vin.

TABLE II

LIST OF SOME IMPORTANT GREEK GRAPES AND ACREAGES

| Varieties | Chief Geographic Locations | Area (Acres) |
|---|---|---|
| | *Table Grapes* | |
| Fraoula | North Peloponnesus, Corinthia, Cyclades | 2,229 |
| Rhazaki | Crete, northern Peloponnesus, northern Greece, Dodecanese | 13,906 |
| Sideritis | Achaia, Attica, Euboea | 2,605 |
| All others | | 18,175 |
| Total | | 36,915 |
| | *Raisin Grapes* | |
| Black Corinth | Peloponnesus | 107,687 |
| Sultanina | Peleponnesus, Crete | 37,830 |
| All others | | 2,645 |
| Total | | 148,162 |
| | *Wine Grapes* | |
| *White:* | | |
| Asyrtico | Cyclades | 4,735 |
| Athiri | Cyclades, Dodecanese | 576 |
| Moschato aspro | Samos, Cyclades, northern Peloponnesus, Ionian isles | 5,556 |
| Savatiano | Attica, Boeotia, Peloponnesus, Cyclades, Crete | 104,670 |
| *Red:* | | |
| Fileri | Peloponnesus, Ionian isles | 18,542 |
| Kotsifali | Cyclades, Crete | 832 |
| Liatico | Crete, Cyclades, western Peloponnesus, Zante | 9,097 |
| Mavrodaphne | Achaia, Cephalonia | 1,740 |
| Rhoditis | Northeast Peloponnesus, Attica, Boeotia, Euboea | 35,015 |
| Romeico | Crete | 10,735 |
| Vartzami | Lefkas, Ionian isles, western Greece | 8,865 |
| All other wine grapes | | 172,430 |
| Total | | 372,793 |

Fig. 11. View of portion of the Rhazaki Bowl about 5 miles south of Heraklion, Crete. Except for the bottom land the topography is hilly, the land terraced, and the soil very calcareous.

overhead arbors. The berries are large and ellipsoid, and have a pleasing flavor. This very vigorous and productive crop ripens at the end of August. On head-trained vines spurs 2 to 4 buds long are often retained, and on the arbors half-long canes (5-8 buds) are used. 'Rhazaki' grows well near the sea, where summer temperatures do not rise too high. The variety is subject to coulure (poor set of berries after bloom) and millerandage (presence of small berries). The Greeks consider it a good keeping and shipping grape. Much of this white-seeded grape is used for export.

*'Sideritis'* ranks second to 'Rhazaki' in importance as a table grape. The clusters are large, loose, elongated, and cylindrical or conical. The berries are large and ellipsoid, have a thick skin, violet-red color, crisp flesh, and are seeded. This vigorous and productive cultivar is late-maturing, being harvested after the middle of October. It is head-trained, with a trunk, or grown on overhead arbors. The spurs retained are 4-5 buds long when arbors are used, and 2-3 buds long otherwise. This grape is subject also to coulure, and to millerandage, and rotting. In dry harvesting seasons it is considered a good keeping and shipping grape, and is used for export.

*'Fraoula'* is a red, seeded table grape found in small plots throughout Greece. The clusters are elongated, cylindrical or conical, and loose. The berries are very large and ovoid, with a fine skin of red-violet color, and a firm flesh of neutral taste. The crop is harvested about the middle of September. These vigorous and very productive vines are head-trained, and often have 5-7 arms, each

with a 2-4 bud spur. This variety, too, is subject to coulure and millerandage, sensitive to downy mildew and rot, and is considered only fairly good for keeping and shipping.

Some 'Sultanina' are used for table grapes; more are exported as raisins. One often finds 'Black Corinth' for fresh sale in the Athens markets.

**Raisin Grapes.** *'Black Corinth.'* Greek viticulture is probably best known for its production of the 'Black Corinth' ('Zante currant') grape (12). The dried currants of commerce, made from this grape, are widely used in everyday cooking and by the bakery trade in cakes and puddings and for other purposes. The name "currant" has no doubt gradually evolved from the name Corinth, the port from which Western Europe received its early supply of currants.

When phylloxera destroyed most of the French vineyards, in the late 19th century, there was a heavy demand for dried currant grapes to be used in the manufacture of wine and brandy (1, 11). After 1876 the acreages in Greece were greatly expanded to fill this need. French vineyards, however, were re-established on American rootstocks, and France imposed taxes on imported dried currants in 1883-84. The French market then soon disappeared, producing a crisis in Greece. In 1895 a Retention Act was passed by the Greek government to control yearly output and prevent overstocking the markets. Growers had to deposit a certain percentage of their currants in Greek government warehouses in order to obtain permission to export the rest. The currants retained enabled the government to promote the making of wine and brandies. In 1925 the Autonomous Central Currant Office was created. It had the function of buying surplus currants and guiding the government in legislation pertaining to currants. The Currant Institute, administered by the Currant Board, conducts research on improving the quality of currants, and provides services to growers, including weather forecasts. The chief institute, at Pyrgos, in the Peloponnesus, seemed to the author to be definitely handicapped by lack of funds. The Agricultural Bank of Greece procures Bordeaux, sulphur, and other materials needed by grape growers, and fosters the organization of grower cooperatives.

Most of the 'Black Corinth' is grown in a strip along the northern coast of the Peloponnesus, beginning near Corinth and extending to Patras, around the northwest corner and down the west coast (14). This narrow strip is about 250 miles long. Corinth, Aeghion, Patras, Amalias, Kyparessia, Pyrgos, Pylos, and Kalamata are some of the important regions. The Ionian Islands of Zante and Cephalonia are also of importance. In 1901, David Fairchild, Agricultural Explorer for the U.S. Department of Agriculture, sent cuttings from Panariti, a village near Aeghion, to the United States for propagation (10).

'Black Corinth' is quite susceptible to downy and powdery mildew. The vines are head-trained and usually pruned to 2- or 3-bud spurs. Formerly, wine was made from the dried raisins, but only the fresh grapes may now be so used. One strain, found occasionally, fails to set fruit. It is called 'Anthusa.' The author sprayed some of these vines with the plant regulator 4-chlorophenoxyacetic acid (4CPA) and obtained a good set of seeded berries.

*'Sultanina.'* This variety is grown mainly in Corinthia and in Crete, especially near Heraklion and Sitia. It is topped several times throughout the season. It is head-trained and usually pruned to half-long canes. In some locations there is no trunk (Fig. 6).

Currant quality varies with the area of production. The six types of currants recognized by the trade, in order of quality with regions shown in paren-

theses, are: 1) 'Aeghion' (Vostizza); 2) 'Gulf' (Corinthia); 3) 'Patras'; 4) 'Amalias' (Ionian islands, Gargaliani, Kyparissia); 5) 'Pyrgos'; and 6) 'Provincial' (Olympia, Pylia, Messinia).

**Wine Grapes.** *'Asyrtico,'* grown in the Cyclades, makes up about three-fourths of the production in the island of Thira. The cylindrical clusters are of medium size. The medium to large berries have a golden-yellow skin and are soft, juicy, and rich in tannins. Ripening is usually in mid-September. The vine is head-trained, and the canes are interlaced at the ends to form a basket. This variety, the principal constituent of the best wines of the Cyclades, is very sensitive to attacks by downy and powdery mildew.

*'Athiri'* has compact medium size clusters. The spherical berries are of medium size and have fine skin, golden-yellow color, and soft, juicy flesh. The very productive vines are head-trained and spur-pruned. The fruit matures in September.

*'Fileri'* has clusters and berries of medium size. The thick skin is a reddish-violet. The berries are juicy and rich in tannins. The vigorous vines, head-trained (usually with no trunk) or spur-pruned, mature at the end of September. This variety is very sensitive to downy mildew and coulure. It is blended with others, to produce some of the best Greek wines.

*'Kotsifali.'* The clusters are conical and of average size, with ellipsoid berries, a thick, dark violet skin and soft flesh. Maturity is reached at the end of August and the beginning of September. The vigorous vine is head-trained, spur-pruned, and very susceptible to downy and powdery mildew. Wines from this variety are characterized by a brilliant color.

*'Liatico.'* The clusters are cylindrical, compact, and of average size. The berries are medium-large, with a fine bluish-black skin and very juicy flesh. Ripening is in mid-July. The vine is very vigorous, head-trained, and spur-pruned. The variety is quite drought-resistant.

*'Mavrodaphne'* has cylindrical clusters of average size. The violet-black skin is of average thickness and color. Maturation begins in early September. The vigorous and productive vines, head-trained and spur-pruned, are susceptible to coulure, and to attacks by downy and powdery mildew. The variety is used to produce an excellent sweet wine.

*'Moschato aspro'* (syn. *'Muscat de Frontignan'*). In this variety the clusters are of average size, cylindrical, and compact with spherical golden-yellow berries which have a skin of medium thickness. The flesh is of medium consistency, with a muscat flavor. Maturity is reached from the end of August to the end of September. The vines are productive and of medium vigor; head-trained and spur-pruned. The variety, susceptible to attacks of downy mildew, furnishes the main constituent of the famous wines of Samos.

*'Rhoditis.'* This variety has medium to large, cylindrical clusters of medium compactness. Its large, spherical berries are rose-violet, with thin skins and soft flesh. Maturity is reached by mid-September to the end of October. The vigorous vines, of average productivity, are head-trained and spur-pruned. This variety, subject to coulure and downy mildew, is excellent for use for white and rose wines.

*'Romeico.'* This grape is probably an introduction from Venice. The cluster is compact and of average size with spherical berries of medium-size, blue-violet color, and thick skins. Harvest is from mid-September to mid-October. These vigorous and productive vines are head-trained, spur-pruned, and susceptible to downy mildew. The wine is distinguished by its deep color.

*'Savatiano'* is the most important wine grape. Its clusters are cylindrical-conical, very compact, of medium size, and with a short peduncle. The berries are spherical, of medium size, with a yellow skin of average thickness, and soft, very juicy flesh. Ripening is from mid-September to mid-October. Vigor is average, but production is excellent even under adverse conditions. This variety, head-trained and spur-pruned to one or two buds, is resistant to drought and powdery and downy mildew. The wine, of high alcoholic content is a white wine that turns reddish on aging. The best retsina wine (resin wine) is derived from this variety. For the best results it is usually mixed with 10 per cent 'Rhoditis.'

*'Vartzami.'* Ninety per cent of the grapes of Lefkos are 'Vartzami.' The clusters are of average size, cylindrical-conical and compact. The berries are small and spherical; the thick skin is a dark-violet red; the flesh is soft and juicy. Harvest is at the end of September. The vigorous and very productive vines are trained to a low head with 2 to 4 arms and spur-pruned. The wines have much color and are used for blending.

## Production and Exports

The yields are usually around five tons of fruit per acre for 'Rhazaki' and 'Fraoula' and around four tons for 'Sideritis.' Usually, 'Black Corinth' and 'Sultanina' for raisins, respectively produce 3 to 4 and 4 to 5 tons of fresh fruit per acre. The production of wine grapes is usually two to three tons per acre. The 'Rhazaki' makes up 70-90% of the total table grapes exported. Second in importance is 'Sideritis.' Of minor importance are 'Opsimo Edessis,' 'Muscat Hamburg,' and 'Petinos.' In 1957, 19,881 tons of table grapes were exported. The trend is for a larger tonnage of table grapes for export each year. In 1953, for example, only 9,442 tons were exported. Respective average yearly exports of 'Black Corinth' and 'Sultanina' for raisins in 1955 to 1957, inclusive, were about 58,000 and 49,000 tons. The main importers of Greek raisins were England, Ireland, West Germany, and Holland.

## Wine Making

The art of wine making always accompanies culture of the vine. In Greece the *vin ordinaire* is the retsina, or resin, wine. A resin from pine trees is added as a preservatve. The resin imparts a definite taste of varnish especially in wines that have a high percentage of added pine pitch. Retsina is very popular in Greece, but has never become popular in other countries—and very likely never will.

According to Davides (8) there are about 47 winery cooperatives and 94 privately owned wineries in Greece. The total annual production of wine in Greece is around 100,000 gallons. About 5% of the total production is exported, mainly to West Germany, Belgium, France, and Italy. The most famous of the Greek wines are Mavrodaphne and Samos wines. These are available in the United States.

## Acknowledgments

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# A Comparative Phytochemical Study of Polish and American Varieties of Poria obliqua[1]

JOAN H. WINTERS, CHARLES H. BECKER and WERNER M. LAUTER[2]

Because considerable interest has been shown in Poland over *Poria obliqua* (Pers.) Karst. in the fight against cancer, we decided to make a comparative preliminary phytochemical study of the American and Polish varieties of this fungus. *Poria obliqua,* or Blackening Birch Bark, has been used in Eastern Europe as a folk remedy against cancer. This fungus is also found in the United States and is reported to be botanically identical (1). The per cent moisture content, total ash, and acid-insoluble ash of both varieties were determined and compared. Both were extracted by a modified Stas-Otto method and the extracts were examined. Although no alkaloids or glycosides were detected, the presence of tannins and sterols was indicated. A chromatographic analysis was made of the ether-soluble, water-insoluble fractions from both fungi. Two constituents were isolated from each variety of fungus, and the infrared spectra of these compounds are described and discussed.

Besides the name *Poria obliqua, Polyporus nigricans* and *Fomes ignarius* have sometimes been used to name this fungus. We are indebted to Professor Erdman West of the University of Florida Agriculture Experiment Station for positive identification of the two samples of the fungus used in this investigation.

The therapeutic and phytochemical literature is scanty (2, 3, 4, 5) and no preliminary investigation had been carried out to determine if close phytochemical relations existed between plant material obtained from Eastern Europe and the United States. It was the object of this investigation to clarify this point. The European material was obtained through the courtesy of Mgr. S. Piaskowski of Warsaw, Poland. The American variety was kindly furnished by Dr. W. A. Campbell of the U.S. Department of Agriculture, Forest Service.

### Experimental

The Polish fungus was collected from the trunk of a decaying *Betula lenta* L. tree grown near Warsaw. The American material was obtained from the trunk of a *Betula lenta* tree grown in the vicinity of the Southwest Forest Experiment Station near Franklin, N. C.

Both samples were ground to a 40 mesh powder.

Moisture Content (100°C.)

| | |
|---|---|
| Polish variety: 17.12% | Average of 3 samples each |
| American variety: 12.07% | |

Total Ash (U.S.P.XV Procedure)

| | |
|---|---|
| Polish variety: 8.93% | Average of 3 samples each |
| American variety: 6.63% | |

Acid-insoluble Ash (U.S.P.XV Procedure)

| | |
|---|---|
| Polish variety: 0.14% | Average of 3 samples each |
| American variety: 0.11% | |

[1]This paper is based on a Thesis presented to the Graduate School of the University of Florida by Joan H. Winters in partial fulfillment of the requirements for the degree of Master of Science in Pharmacy.

[2]College of Pharmacy, University of Florida, Gainesville, Florida.

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**Alcoholic Extraction.** Both samples were treated in an identical manner. Two hundred fifty g. of powdered fungus was allowed to macerate at room temperature with 750 ml. of 92.5% ethanol. It was found that the solvent was nearly neutral and 150 ml. of a 10% tartaric acid solution in 92.5% ethanol had to be added to the Polish sample, and 100 ml. to the American material before a pH of approximately 5.0 was reached (pHydrion paper). After maceration for 18 hours the samples were filtered and the solvent part retained for use as menstruum in the subsequent percolations (No change in pH were noted). The marcs differed greatly in color; the Polish variety was dark brown, the American yellowish-brown in color. The damp marcs were then packed into percolators and the filtrate added again. The materials were then percolated at a moderate rate and washed with 92.5% alcohol until the liquids were nearly colorless. The marcs were dried (finally in vacuo), weighed, and the per cent acidified-alcohol-soluble material calculated on a moisture free basis (See "Alcoholic Extractible Constituents," Table II). The alcohol was recovered *in vacuo* at a temperature below 50°C.

**Fractionation of Extracts.** Both varieties of *Poria obliqua* deposited precipitates in the alcohol-free aqueous concentrate. The material was filtered, washed with water and dried *in vacuo* to constant weight (See "Water-insoluble Constituent from Alcoholic Extracts," Table II).

The aqueous filtrates were then concentrated *in vacuo* to a thick consistency at temperatures not exceeding 50°C. Absolute alcohol was added to the concentrates until no further precipitation occurred. A small amount of tan-colored amorphous material precipitated in both cases. Upon filtration and subsequent drying, the precipitate was weighed (See "Absolute alcohol-insoluble Constituents from Alcoholic Extract," Table II). Both powders decomposed without melting above 360°C.

The alcohol filtrates were then evaporated at temperatures below 50°C. until a syrupy consistency was obtained. A clear solution was obtained upon addition of warm distilled water. The presence of glycosides, tannins and alkaloids as tartrate salts was investigated in this aqueous solution (Table I).

**Fractionation of Water-Insoluble Precipitates.** The water-insoluble precipitates obtained from the concentration of the alcoholic extracts were further examined. The possibility of the presence of acidic compounds was determined by maceration with five per cent sodium carbonate solution at room temperature for twelve hours. Upon filtration, the liquid portions were slowly precipitated with HCl and the precipitates after washing were dried in vacuo. The percentage of sodium carbonate soluble constituents in the water-soluble precipitates is shown in Table II.

These acidic fractions of both varieties were investigated as to their solubilities in various organic solvents. Acetone separation was finally chosen as the most promising one. Soxhlet extraction until a colorless circulating solvent was obtained, followed by evaporation of the acetone and subsequent drying in vacuo gave the results of "Acetone-Soluble

TABLE I

TESTS OF AQUEOUS SOLUTIONS OBTAINED FROM ALCOHOLIC EXTRACTS

| *Reagent* | *Results* | |
|---|---|---|
| | *Polish* | *American* |
| Mayer's Reagent | Negative | Negative |
| Valser's Reagent | Negative | Negative |
| Wagner's Reagent | Negative | Negative |
| Picric Acid | Negative | Negative |
| 20 Per Cent Alcoholic Alpha-Naphthol Solution and Concentrated Sulfuric Acid | Negative | Negative |
| Ferric Chloride Test Solution | Positive (Dark blue color) | Positive (Dark blue color) |

Constituents from Sodium Carbonate-Soluble Material" (Table II).

The residue remaining after extraction with aqueous sodium carbonate was then investigated for presence of phenolic substances by further extraction with cold 2 per cent sodium hydroxide solution. It was observed after filtration that the filtrate from the Polish material was dark brown in color while the American sample was light brown. Upon careful addition of diluted HCl solution to assure acidity precipitates were obtained. Upon filtration, washing and drying *in vacuo*, the weights of these "Sodium Hydroxide Soluble Constituents of the Water-Soluble Precipitates" (Table II).

After the removal of acidic and phenolic constituents, the residues remaining after sodium hydroxide extractions were dried and extracted with ether. After filtration, washing with more ether and drying, the ether-insoluble material was weighed (Table II).

The ethanol filtrates were evaporated and the dried residues are reported in Table II.

TABLE II
PER CENT OF VARIOUS FRACTIONS IN FUNGI AND EXTRACTS

| Fractions | Per Cent of Various Fractions | |
|---|---|---|
| | Polish | American |
| Alcoholic Extractible Constituents | 3.13 | 5.45 |
| Water-Insoluble Constituents from Alcoholic Extracts | 59.91 | 66.79 |
| Absolute Alcohol-Insoluble Constituents from Alcoholic Extracts | 0.19 | 0.06 |
| Sodium Carbonate-Soluble Constituents from Water-Insoluble Material | 21.50 | 44.11 |
| Acetone-Soluble Constituents from Sodium Carbonate-Soluble Material | 59.85 | 78.77 |
| Sodium Hydroxide-Soluble Constituents from Water-Insoluble Material | 13.02 | 17.95 |
| Ether-Soluble Constituents from Water-Insoluble Material | 55.41 | 24.63 |

**Chromatographic Analyses of The Ether-Soluble Fractions of the Water-Insoluble Precipitates.** Qualitative tests were carried out on these residues for the presence of sterols. Both samples gave positive Liebermann-Burchard reactions. Rosenheim's reagent proved to be negative.

A column was prepared using 80-200 mesh alumina for chromatography as the absorbent. The column dimensions were 25 cm. x 2.3 cm. Benzene solutions of the ether-soluble fractions upon further development with benzene showed a blue fluorescence throughout the entire length of the column. Upon further benzene development the fluorescent portion could be eluted quantitatively.

Upon evaporation of the solvent in the eluate, 0.201 gm. of a viscous oil representing 18.9% of the ether-soluble material from the American sample was isolated. Its refractive index at 30° was 1.6000. It gave negative Liebermann-Burchard and Salkowski reactions. The Polish sample chromatographed in identical manner gave 0.0876 gm. of a viscous yellow oil representing 8.8% of the total chromatographed material. Its refractive index at 30° was 1.4810. It also did not exhibit a charactertistic Liebermann-Burchard or Salkowski reaction.

Both blue fluorescent oils were investigated as to their infrared spectra using a Perkin-Elmer Model 137 Infrared Spectrophotometer with a sodium chloride prism. The spectrum of the Polish sample is shown in Fig. 1 and that of the American one in Fig. 2.

The spectrum of the compound isolated from the Polish variety shows significant absorption peaks at 3.38, 5.75, 6.25, 6.85, and 7.30 microns. The absorption at 3.38 microns is due to the stretching of carbon-hydrogen bonds. No indication of an aromatic structure is demonstrated. The peak at 5.75 microns is indicative of a carbonyl group. The bend at 6.25

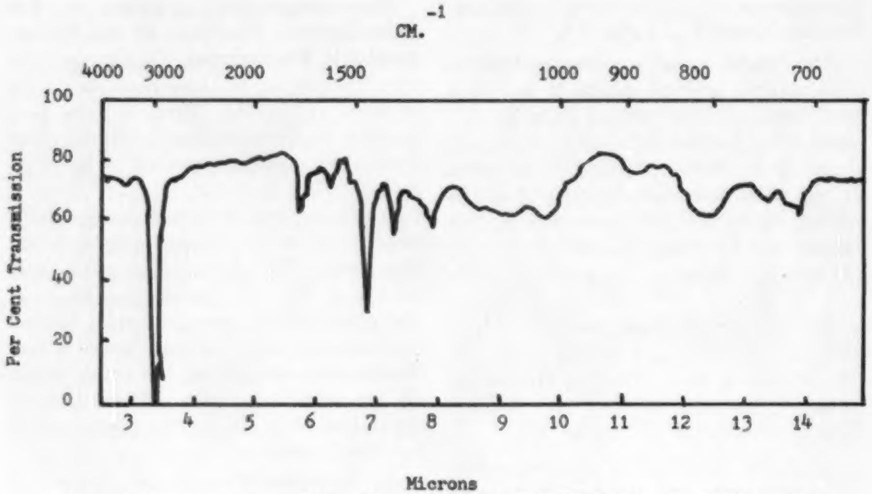


*Fig. 1. Infrared spectrum of the blue fluorescing oil isolated from the Polish variety.*

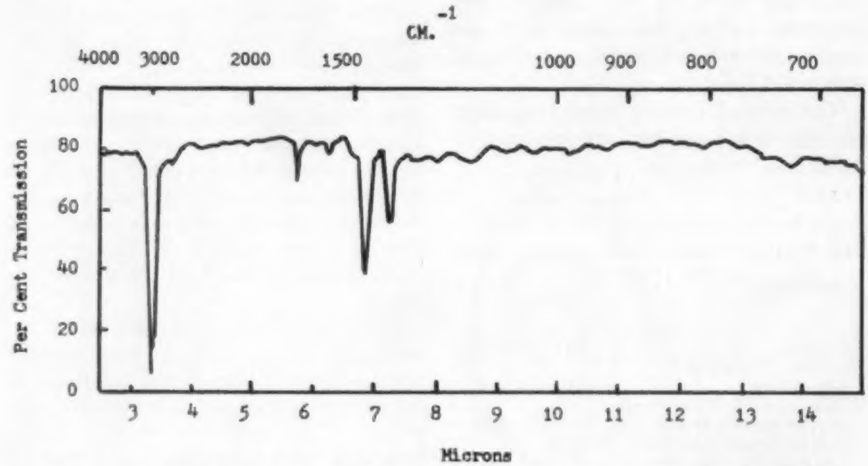


*Fig. 2. Infrared spectrum of the blue fluorescing oil isolated from the American variety.*

microns is probably due to a carbon-nitrogen double bond. The peak at 6.85 microns shows the presence of a methyl group. Again a comparison of the intensity of absorption between these two groups shows that there are more methylene than methyl groups present in the molecule.

The spectrum of the compound isolated from the American variety shows several characteristics similar to the compound isolated from the Polish variety; however, dissimilarities are also demonstrated. The peak at 3.40 microns is due to the stretching of carbon-hydrogen bonds. There is no indication that

the compound is aromatic. The band at 5.75 microns indicated the presence of a carbonyl group; however, the shoulder at 5.85 microns in this band suggests that there may also be present a double bond of some type other than a carbon-oxygen double bond. The peak at 6.25 microns is also probably due to a carbon-nitrogen double bond. At 6.85 microns and 7.30 microns, peaks characteristic of methylene and methyl groups are demonstrated. A comparison of the intensity of absorption between the two groups shows that there are more methylene than methyl groups present in the molecule. At 7.93 microns, the compound isolated from the American variety shows a distinct peak while the compound from the Polish variety does not. This peak may be due to a stretching of a carbon-carbon bond. The absorption in the region between 12 microns and 14 microns suggests the possibility that the compound isolated from the American variety has a larger, more complex structure, with perhaps more branching of the molecule, than the compound obtained from the Polish variety of the fungus.

After the eluting of the blue fluorescent portion, it was found that further development with benzene produced two closely associated green-fluorescent bands in the American sample and only one green-fluorescent band in the Polish variety. These bands were isolated by extrusion and physical separation followed by Soxhlet extraction with methanol. until the circulating liquid no longer fluoresced green. Upon evaporation of the methanol the American material yielded two yellow powders, the m.p. of both was between 127-148°. The Polish variety gave one yellow powder, m.p. 132-156.5°.

All three solids exhibited an olive-green color with the Liebermann-Burchard reagent. Attempts to obtain lower melting points by recrystallization from methanol, acetone and isopropanol were unsuccessful in each instance.

**Infrared Spectra of the Absolute Alcohol-Insoluble Fraction Obtained from Alcohol Extracts.** Because these very small fractions might be fairly pure compounds although they gave no melt-

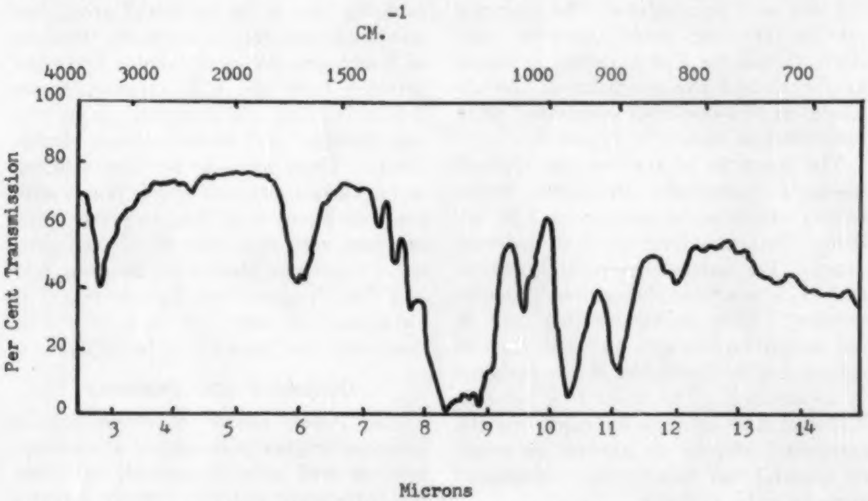


*Fig. 3. Infrared spectrum of the absolute alcohol-insoluble constituent from the Polish variety.*

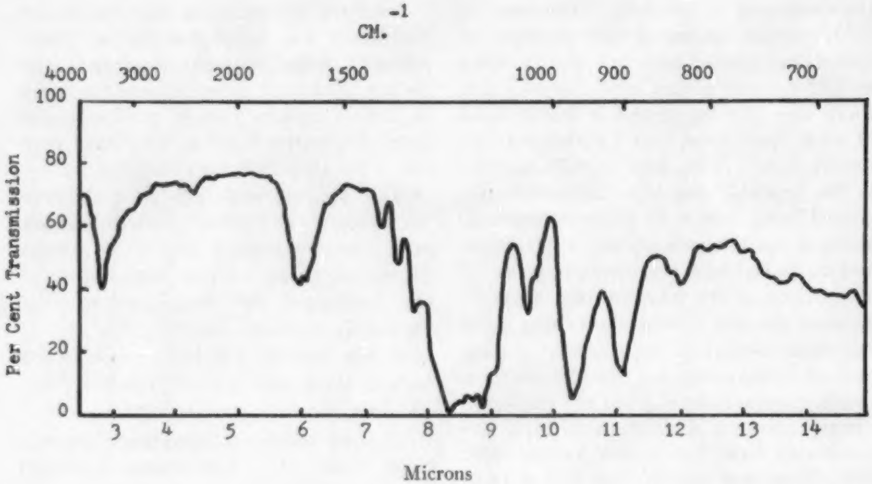


*Fig. 4. Infrared spectrum of the absolute alcohol-insoluble constituent from the American variety.*

ing points, but decomposed above 360°, it was thought advisable to examine their infrared spectra to see if they showed structural relationships. A Perkin-Elmer Model 137 mstrument with a sodium chloride prism was used. Kel F. No. 3 Oil was used as a solvent. The spectrum for the absolute alcohol-insoluble constituent from the Polish variety is shown in Fig. 3 and the spectrum of the absolute alcohol-insoluble compound from the American variety in Figure 4.

The spectrum of the absolute alcohol-insoluble constituent from the Polish variety shows an absorption at 2.85 microns. This is indicative of a hydroxyl group. The band between 6.00 microns and 6.15 microns shows much double bonding. This double bonding may be due to carbon-nitrogen and also carbon-carbon double bonds but is not carbonyl in appearance. The absorption between 8.35 and 8.95 microns indicates that the compound may be an alcohol, an ether, or possibly an ester. The compound appears to be aliphatic.

The spectrum of the absolute-insoluble constituent of the American variety has an absorption peak at 2.95 microns while the constituent from the Polish variety demonstrated absorption at 2.85 microns. This may represent a difference which is significant. The peak at 2.95 microns is probably due to an hydroxyl group but also might possibly indicate the presence of a nitrogen-hydrogen bond. The band between 6.00 and 6.25 microns shows double bonding which appears to be carbon-nitrogen and carbon-carbon double bonds. There seems to be more splitting of the carbon-nitrogen double bonds with the constituent from the American variety than with that from the Polish variety. Again the absorption between 8.35 and 8.95 suggests that the compound is an alcohol, an ether, or an ester. This compound also appears to be aliphatic.

## Discussion and Summary

The Polish sample of *Poria obliqua* possessed higher percentages in moisture total as well as acid-insoluble ash than the American material. Both samples showed absences of alkaloids and glyco-

sides. Tannins appear to be present in both. Solvent and alkali separations establish the fact that both materials contain similar fractions, although in rather greatly differing percentages. A very small fraction, absolute alcohol-insoluble portion of the alcoholic extract, appears from spectrophotometric data to be quite similar but not identical for both samples, probably representing aliphatic alcohols, ethers or possibly esters.

The ether-soluble fractions indicate strongly the presence of sterols, as well as two oily constituents which differ in refractive index as well as in their infrared spectra. The oil from the American sample appears to be more complex and contains a characteristic additional double bond in the carbonyl region which is definitely lacking in the Polish material.

It is logical to suggest that the chemical constitution of the two varieties, while similar, is not the same. It should be borne in mind that the color of the two samples differed greatly, and that the darker color of the Polish variety might well indicate that this material is older, and that the aging process may be responsible for the variations observed.

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# Seed Extracts with Agglutinating Activity for Human Blood[1]

K. F. SCHERTZ,[2] W. C. BOYD,[3] W. JURGELSKY, JR.,[4] and E. CABANILLAS[4]

***Seed extracts of 311 species of plants were observed for agglutinating activity with human blood cells in an attempt to find plant sources of naturally occurring hemagglutinins for specific blood types. Of the 45 species with specific activity, Bauhinia variegata L. is promising as a source of anti-N agglutinin.***

## Introduction

The typing of human blood is a useful, often a necessary, procedure in medical, medico-legal, and anthropological work. The present demand for blood-typing reagents is large and in wartime could far exceed the supply. Most of the reagents are obtained from animals or, as in the case of the Rh reagent, from human donors. Agglutinins from animals are limited in supply and expensive to produce, and human donors are not always readily available.

Certain plants have been found to possess hemagglutinins which can be used to produce blood-typing reagents. The substances can be extracted from the plant parts which contain them and used in the same way as agglutinins from animal sources. They have the advantage of being economical to produce and quickly available in large quantities in case of an emergency. At present, seed of *Dolichos biflorus* L. is in commercial production as a source of anti-$A_1$ agglutinin.

The purpose of this study was to find other suitable plant sources of agglutinins for known blood types and possibly to obtain plant agglutinins for new specificities. A plant source to be useful must (1) have an agglutinin with specificity for a particular blood factor, (2) have the agglutinin present in adequate concentration, and (3) produce a large amount of the plant part in which the agglutinin is contained. Also, it must meet requirements imposed by the producer for economic production.

In 1888 Hermann Stillmark, while carrying out his Ph.D. research in pharmacology with R. Kobert in Dorpat, found that an extract of the poisonous castor bean *(Ricinus communis)* agglutinated the red blood cells of various animals (24, 25). He found extracts of *Croton tiglium* to act similarly. Later work extended these investigations to *Abrus precatorius* and *Robinia pseudoacacia*. These first discovered plant agglutinins were also toxins, but Landsteiner and Raubitschek (20) found that extracts of edible beans and other legumes also had agglutinating power. *Canavalia ensiformis* seed was later found by Sumner and Graham (26) to contain an hemagglutinating substance.

Later workers proceeded to find agglutinins in the seeds of a number of

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[2]Address: USDA, ARS, Texas A & M, College Station, Texas.

[3]Address: Boston University School of Medicine, Boston 18, Mass.

[4]Address: Federal Experiment Station, Mayaguez, Puerto Rico.

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plants, and Landsteiner (19) pointed out that these plant proteins were not without a certain degree of specificity in their action on the blood of various animal species. Boyd mentioned in 1947 (5) that certain plant agglutinins show a certain degree of specificity in their action on the human red cells. This statement was based on the observation, made in 1945, that some lima beans contain an agglutinin specific for the A antigen of human blood. Renkonen (23) reported on the reactions of extracts of seeds of several legumes, some of which were specific for certain types of blood. Boyd and Ruguera (10) studied the extracts of a large number of plants. Of these, 25 collections were "more or less" blood group specific. Among the 25 were several which reacted with $A_1$ and $A_2$ cells. The reactions of other plants have since been presented by Boyd (6, 7), Elo et al. (14), Cazal and Lalaurie (13), Bird (1), Krüpe (16, 17), Ottensooser and Silberschmidt (24), Boyd and Shapleigh (11), and Bird (2).

Other specificities were listed by Mäkelä and Mäkelä (3), and Bird (3). Mäkelä (21) presented the results of extensive screening and summarized previous work. He found four members of the genus *Bauhinia* that contained weak anti-N agglutinins in the seeds. Boyd, Everhart, and McMaster (8) reported on tests of several species of *Bauhinia*, some of which were found to contain strong anti-N agglutinins, "lectins."[5] Tobiška reported the specificities of species of *Evonymus* (27) *Ulex* and *Lupinus* (28). Explanations for the variation in results among workers are presented by Tobiška (29). Boyd et al. (9) found a weak agglutinin in the peanut (*Arachis hypogaea*) for a factor in some human bloods. This factor has apparently not been identified previously. For reviews of the subject see Krüpe (18) and Bird (4).

[5]The word lectin, from the Latin *legere*, to pick out or choose, was proposed by Boyd (11) for proteins combining specifically with certain antigens or haptens, but not formed as a result of antigenic stimulus.

**Materials and Methods**

Seeds, and occasionally other plant parts, were collected in Puerto Rico from both wild and cultivated plant sources and from plant introductions obtained in connection with research programs at the Federal Experiment Station. The work of others reviewed above indicated that leguminous seeds were probably the most likely sources of hemagglutinins. Therefore, most of the collections for this study were seeds of Leguminosae, but some other species were included.

Identifications were made from preserved specimens collected at the time of seed collection.[6] In those cases where seed was obtained from introduction programs, the identifications supplied by the sender were used. The family classifications in the tables are according to Index Kewensis (15).

The collections were analyzed in the laboratory at Boston University in the following manner: the material was ground, and 1 gram of the meal was extracted overnight with 10 ml. of physiological saline solution. One drop of extract was tested versus one drop of a 1% suspension of red blood cells of each type in physiological saline. The mixture was centrifuged for 1 minute and the degree of agglutination noted. The strength and characteristics of the reactions were noted for suspensions of red blood cells containing antigens $A_1$, $A_2$, B, H, M, N, S, s, C, D, E, c, e, V, $Fy^a$, $Fy^b$, K, $Jk^a$, $Jk^b$, $Le^a$, $Le^b$, $Lu^a$, $Lu^b$, and Js.

[6]The authors are grateful to L. E. Gregory and N. Almeyda, Federal Experiment Station, Mayaguez, P. R., for assisting with the plant identifications, and to the late S. F. Blake, New Corps Research Branch, Beltsville, Maryland, for aid with the nomenclature.

## Experimental Results

569 seed collections of 311 different plant species, in 42 families were tested for activity of naturally occurring agglutinins. Among these the Leguminosae contained the largest number, with 204 species. Some species were represented more than once by collections from different localities.

Species with specific agglutinating activity are listed in Table I. For the 45 species, the blood types with which they reacted, and the relative strength of the agglutination reactions are included.

To be of value for blood typing it is necessary that an extract have a rather strong specific reaction for a given blood type. Within the group listed in Table 1 the plant which probably holds the greatest potential as a commercial source is the legume, *Bauhinia variegata* L., which gave a strong specific reaction with cells of N-type blood. The detailed characteristics of the anti-N reaction of another *Bauhinia* species, *B. purpurea,* were presented by Boyd et al. (12). The seed extracts of some *Bauhinia* species seem to possess the qualities to make these species suitable commercial sources. These plants grow well in tropical and subtropical regions and although trees, they flower and begin to produce seed when between 1 and 2 years old.

The *Dolichos biflorus* L. collections gave strong anti-A reactions as expected (1), and one of them was specific for $A_1$. Some of the other species showed agglutinating specificity for a single blood type but were rather weak. Of these, the strongest was *Phaeomeria speciosa* (Blume) Merrill of the Zingiberaceae, which was specific for B. This species and others which had different reaction strengths among collections should be checked for possible variation within the species.

Seventy-six species gave nonspecific reactions. These are listed in Table II, as are the number of collections of each species and the strength of each reaction.

The 23 species which gave hemolytic reactions are listed in Table III, and the 196 species which gave negative reactions are in Table IV.

TABLE I

PLANT SPECIES WHOSE SEED EXTRACTS GAVE POSITIVE AGGLUTINATING REACTIONS WITH SPECIFIC BLOOD TYPES. MEANINGS OF REACTION NUMBERS ARE 1—VERY WEAK, 2—WEAK, 3—MEDIUM STRONG, AND 4—STRONG. A BLANK MEANS NO AGGLUTINATION.

| Family Species | $A_1$ | $A_2$ | B | O |
|---|---|---|---|---|
| Aristolochiaceae: | | | | |
| *Aristolochia galeata* Mart. & Zucc. | | | 1 | |
| Bignoniaceae: | | | | |
| *Tecoma stans* (L.) HBK. | 1 | 1 | | |
| Bixaceae: | | | | |
| *Bixa orellana* L. | | | 2 | |
| *Cochlospermum gossypium* (L.) DC. | | | | 1 |
| Boraginaceae: | | | | |
| *Cordia glabra* L. | 1 | 1 | | 1 |
| *Cordia obliqua* Vell. | 1 | | | 1 |
| *Cordia* sp. | 2 | 2 | | |
| *Ehretia buxifolia* Roxb. | | | | 2 |
| Compositae: | | | | |
| *Helianthus annuus* L. | | | | 1 |
| Leguminosae: | | | | |
| *Alysicarpus vaginalis* (L.) DC. | | | 2 | |
| *Bandeiraea simplicifolia* Benth. | 1 | | 2 | |
| *Bandeiraea simplicifolia* Benth. | 2 | 4 | 3 | 4 |
| *Bauhinia candicans* Benth. | 1 | | 1 | 1 |
| *Bauhinia macrostachya* Wall. | 1 F | | | 1 F[1] |
| *Bauhinia monandra* Kurz | | | | 1 |

| | | | | |
|---|---|---|---|---|
| *Bauhinia variegata* L.[2] | | | | |
| *Bauhinia* sp. L. | 2 | 4 | 2 | 4 |
| *Caesalpinia mimosoides* Lam. | | 1 | 1 | 1 |
| *Canavalia ensiformis* (L.) DC. | 2 | 2 | 2 | 1 |
| *Cassia glauca* Lam. | | 1 | | 1 |
| *Centrosema plumieri* (Turp.) Benth. | 1 | 1 | | 1 |
| *Crotalaria breviflora* DC. | 2 | 2 | | |
| *Crotalaria intermedia* Kotschy | 1 | 2 | 2 | |
| *Crotalaria intermedia* Kotschy | | | 1 | |
| *Crotalaria mucronata* Desv. | 4 | 2 | | |
| *Crotalaria mucronata* Desv. | 4 | 2 | | |
| *Crotalaria mucronata* Desv. | 4 | 2 | 2 | 2 |
| *Crotalaria mucronata* Desv. | 4 | 2 | | |
| *Crotalaria mysorensis* Roth | 1 | 1 | | 1 |
| *Crotalaria saltiana* Andr. | 4 | 2 | 2 | |
| *Crotalaria* sp. | | 1 | | |
| *Crotalaria* sp. | 4 | 2 | | |
| *Dolichos biflorus* L. | 4 | 2 | | |
| *Dolichos biflorus* L. | 4 | 2 | | |
| *Dolichos biflorus* L. | 4 | 2 | | |
| *Dolichos biflorus* L. | 3 | 2 | | |
| *Dolichos biflorus* L. | 4 | 2 | | |
| *Dolichos biflorus* L. | 4 | 2 | | |
| *Dolichos biflorus* L. | 2 | | | |
| *Dolichos biflorus* L. | 4 | 2 | | |
| *Dolichos biflorus* L. | 2 | 2 | 2 | |
| *Dolichos biflorus* L. | 3 | | | |
| *Dolichos lablab* L. | | 3 | 3 | |
| *Dolichos lablab* L. | 4 | 2 | 2 | 2 |
| *Erythrina poeppigiana* (Walp.) O. F. Cook | 2 | 4 | 2 | 4 |
| *Lupinus luteus* L. | | 4 F | | 4 F |
| *Medicago sativa* L. | 2 F | 4 F | 2 F | 4 F |
| *Medicago sativa* L. | 2 F | 4 F | 2 F | 4 F |
| *Phaseolus lunatus* L. | 4 | 2 | 2 | |
| *Phaseolus ricciardianus* Tenore | | | 2 | |
| *Pueraria lobata* (Willd.) Ohwi | 2 F | | | |
| *Pueraria phaseoloides* (Roxb.) Benth. | | | 2 | |
| *Pueraria phaseoloides* (Roxb.) Benth. | 2 | 2 | | 2 |
| *Rhynchosia minima* (L.) DC. | 2 F | 4 F | 2 F | 4 F |
| *Samanea saman* (Willd.) Merrill | 2 | 4 | 1 | H |
| *Sphenostylis stenocarpa* Harms | 2 | 4 | 2 | 4 |
| *Sphenostylis stenocarpa* Harms | 1 | 4 | 2 | 4 |
| *Sphenostylis stenocarpa* Harms | 2 | 4 | 2 | 4 |
| *Stahlia monosperma* (Tul.) Urban | | 2 | | 1 |
| *Trifolium subterraneum* L. | 2 F | 4 F | 4 F | 4 F |
| *Meliaceae:* | | | | |
| *Cipadessa fruticosa* Blume | 2 | 2 | | 2 |
| *Swietenia candollei* Pittier | 4 | 3 | 3 | H[3] |
| Musaceae: | | | | |
| *Musa textilis* Née | 2 | | | |
| Myrtaceae: | | | | |
| *Eugenia uniflora* L. | 2 | 2 | | 2 |
| Palmae: | | | | |
| *Pinanga kuhlii* Blume | | 2 | | |
| Polygonaceae: | | | | |
| *Triplaris americana* L. | 3 | 3 | | 3 |
| Rubiaceae: | | | | |
| *Coffea arabica* L. | 2 | | | 2 |
| Zingiberaceae: | | | | |
| *Phaeomeria speciosa* (Blume) Merrill | | 3 | | |

[1]F—Reaction of ficinized solution. Other reactions are of non-ficinized.
[2]Strong specific reaction with type N blood.
[3]H—Hemolyzed.

TABLE II

PLANT SPECIES WHOSE SEED EXTRACTS GAVE NONSPECIFIC AGGLUTINATING REACTIONS WITH $A_1$, $A_2$, B, H, M, N, S, s, C, D, E, c, e, V, $Fy^a$, $Fy^b$, K, $Jk^a$, $Jk^b$, $Le^a$, $Le^b$, $Lu^a$, $Lu^b$, and $Js$ HUMAN BLOODS. THE REACTION STRENGTHS LISTED ARE WEAK, WHICH IS COMPARABLE TO REACTIONS 1 AND 2, AND STRONG WHICH IS COMPARABLE TO REACTIONS 3 AND 4 OF TABLE 1

| Family Species | No. of collections | Reaction Strength Weak | Strong |
|---|---|---|---|
| Asclepiadaceae: | | | |
| *Asclepias* sp. | 1 | x | |
| Bignoniaceae: | | | |
| *Spathodea nilotica* Seem. | 1 | | x |
| *Tecoma gaudichaudi* DC. | 1 | x | |
| Combretaceae: | | | |
| *Terminalia muelleri* Benth. | 1 | x | |
| Euphorbiaceae: | | | |
| *Euphorbia* sp. L. | 2 | x | |
| *Hura crepitans* L. | 1 | | x |
| *Ricinus communis* L. | 1 | | x |
| Lauraceae: | | | |
| *Ocotea leucoxylon* (Sw.) Mez. | 1 | x | |
| Leguminosae: | | | |
| *Alysicarpus vaginalis* (L.) DC. | 2 | x | |
| *Bauhinia macrostachya* Wall. | 1 | x | |
| *Bauhinia reticulata* DC. | 1 | x | |
| *Caesalpinia ferrea* Mart. | 1 | x | |
| *Cajanus cajan* (L.) Druce | 2 | x | |
| *Canavalia bonariensis* Lindl. | 1 | | x |
| *Canavalia ensiformis* (L.) DC. | 4 | | x |
| *Canavalia maritima* (Aubl.) Thou. | 3 | | x |
| *Canavalia rugosperma* Urban | 1 | | x |
| *Canavalia villosa* Benth. | 1 | x | |
| *Canavalia* sp. | 1 | | x |
| *Cassia grandis* L. | 1 | | x |
| *Cassia mimosoides* L. | 1 | x | |
| *Cassia patellaria* DC. | 1 | | x |
| *Cassia* sp. | 1 | | x |
| *Calopogonium galactoides* Benth. ex Hemsl. | 2 | x | |
| *Crotalaria anagyroides* HBK. | 1 | | x |
| *Crotalaria breviflora* DC. | 1 | x | |
| *Crotalaria grantiana* Harv. | 1 | x | |
| *Crotalaria juncea* L. | 9 | | x |
| *Crotalaria lanceolata* E. Mey. | 2 | x | |
| *Crotalaria mucronata* Desv. | 1 | x | |
| *Crotalaria paulina* Schrank | 1 | x | |
| *Crotalaria pumila* Orteg. | 1 | x | |
| *Crotalaria usaramoensis* E. Baker | 1 | | x |
| *Crotalaria vitellina* Ker-Gawl. | 1 | x | |
| *Crotalaria zanzibarica* Benth. | 1 | | x |
| *Crotalaria* sp. | 1 | x | |
| *Crotalaria* sp. | 1 | | x |
| *Desmanthus virgatum* (L.) Willd. | 1 | x | |
| *Desmodium diffusum* DC. | 1 | x | |
| *Desmodium discolor* Vog. | 1 | x | |
| *Desmodium polycarpum* (Poir.) DC. | 1 | x | |
| *Desmodium purpureum* (Mill.) Fawc. & Rendle | 1 | x | |
| *Desmodium tiliaefolium* G. Don | 1 | x | |
| *Desmodium uncinatum* (Jacq.) DC. | 1 | x | |
| *Dolichos biflorus* L. | 1 | x | |
| *Dolichos debilis* Hochst. ex. A. Rich. | 1 | x | |
| *Dolichos lablab* L. | 13 | x | |
| *Dolichos lablab* L. | 8 | | x |
| *Erythrina berteroana* Urban | 1 | | x |
| *Erythrina glauca* Willd. | 1 | | x |
| *Galactia striata* (Jacq.) Urban | 1 | | x |
| *Galactia* sp. | 2 | | x |
| *Glycine max* (L.) Merr. | 2 | | x |

| | | | |
|---|---|---|---|
| *Indigofera cytisoides* L. | 1 | x | |
| *Indigofera hirsuta* L. | 1 | x | |
| *Indigofera suffruticosa* Mill. | 1 | x | |
| *Indigofera sumatrana* Gaertn. | 1 | | x |
| *Indigofera* sp. | 1 | x | |
| *Lathyrus hirsutus* L. | 1 | x | |
| *Lespedeza bicolor* Turcz. | 1 | x | |
| *Parkia biglandulosa* W. & A. | 1 | | x |
| *Parkia speciosa* Hassk. | 1 | | x |
| *Phaseolus aconitifolius* Jacq. | 1 | x | |
| *Phaseolus calcaratus* Roxb. | 1 | | x |
| *Psophocarpus tetragonolobus* (L.) DC. | 4 | | x |
| *Sesbania grandiflora* (L.) Poir. | 1 | x | |
| *Stizolobium aterrinum* Piper & Tracy | 1 | x | |
| *Teramnus labialis* (L.f.) Spreng. | 2 | x | |
| *Teramnus* sp. | 1 | | x |
| *Trifolium alexandrinum* L. | 1 | x | |
| *Vicia angustifolia* L. | 1 | x | |
| *Vicia gemella* Crantz | 1 | | x |
| *Vicia hirsuta* S. F. Gray | 1 | x | |
| *Vicia menziesii* Sprengel | 1 | x | |
| *Vicia sativa* L. | 1 | x | |
| *Vigna repens* (L.) Kuntze | 3 | x | |
| *Vigna sinensis* (Torner) Savi | 1 | x | |
| *Vigna* sp. | 1 | x | |
| Melastomataceae: | | | |
| *Clidemia hirta* (L.) D. Don | 1 | x | |
| Myrsinaceae: | | | |
| *Rapanea guianensis* Aubl. | 1 | x | |
| Myrtaceae: | | | |
| *Callistemon* sp. | 1 | x | |
| Polygalaceae: | | | |
| *Securidaca* sp. | 1 | x | |
| Rosaceae: | | | |
| *Rubus glaucus* Benth. | 1 | | x |
| *Rubus rosaefolius* Smith | 1 | | x |
| Rubiaceae: | | | |
| *Pterocarpus* sp. | 1 | | x |
| *Randia formosa* (Jacq.) K. Schum. | 1 | | x |
| Simarubaceae: | | | |
| *Quassia amara* L. | 1 | | x |
| Solanaceae: | | | |
| *Solanum* sp. | 1 | x | |
| Sterculiaceae: | | | |
| *Dombeya natalensis* Sond. | 1 | x | |
| Verbenaceae: | | | |
| *Clerodendron squamatum* Vahl | 1 | | x |
| *Siphonanthus indicus* L. | 1 | | x |

TABLE III

PLANT SPECIES WHOSE SEED EXTRACTS GAVE HEMOLYTIC AGGLUTINATING REACTIONS WITH $A_1$, $A_2$, B, H, M, N, S, s, C, D, E, c, e, V, $Fy^a$, $Fy^b$, K, $Jk^a$, $Jk^b$, $Le^a$, $Le^b$, $Lu^a$, $Lu^b$, AND Js HUMAN BLOODS.

| Family | Species |
|---|---|
| Apocynaceae: | |
| | *Tabernaemontana citrifolia* L. |
| Leguminosae: | |
| | *Albizzia chinensis* (Osbech) Merr. |
| | *Alysicarpus glumaceus* DC. |
| | *Bauhinia retusa* Roxb. |
| | *Bauhinia* sp. |
| | *Caesalpinia minosoides* Lam.[1] |
| | *Cajanus cajan* (L.) Druce |
| | *Calopogonium galactoides* Benth. ex Hemsl. |
| | *Canavalia ensiformis* (L.) DC. |
| | *Centrosema plumieri* (Turp.) Benth. |
| | *Clitoria ternatea* L. |
| | *Clitoria* sp. |
| | *Crotalaria tetragona* Roxb. |
| | *Desmodium nicaraguense* Oerst. ex Benth |
| | *Dolichos* sp. |
| | *Phaseolus adenanthus* G. F. W. Meyer |
| | *Phaseolus calcaratus* Roxb.[2] |
| | *Piptadenia peregrina* (L.) Benth. |
| | *Pithecolobium dulce* (Roxb.) Benth. |
| | *Pithecolobium* sp. |
| | *Sesbania aegyptiaca* Poir. |
| | *Sesbania* sp. |
| Passifloraceae: | |
| | *Passiflora quadrangularis* L.[2] |
| Rubiaceae: | |
| | *Gardenia grandiflora* Lour. |
| Sapotaceae: | |
| | *Achras sapota* L. |

*Mimusops elengi* L.
Solanaceae:
*Solanum sodomeum* L.
Zingiberaceae:
*Phaeomeria speciosa* (Blume) Merrill[4]

[1]Hemolyzed Kell + blood, negative vs. all others.
[2]Hemolyzed $A_2$ blood, negative vs. all others.
[3]Hemolyzed O blood, negative vs. all others.
[4]Hemolyzed B and O bloods, negative vs. all others.

## Table IV

Plant species whose seed extracts gave no agglutinating reactions with $A_1$, $A_2$, B, H, M, N, S, s, C, D, E, c, e, V, $Fy^a$, $Fy^b$, K, $Jk^a$, $Jk^b$, $Le^a$, $Le^b$, $Lu^a$, $Lu^b$, and Js human bloods.

Anonnaceae: *Annona squamosa* L., *Artabotrys* sp., *Polyalthia suberosa* (Roxb.) Benth. & Hook., *Uvaria* sp.
Apocynaceae: *Allamanda neriifolia* Hook., *Carissa grandiflora* A. DC., *Ochrosia elliptica* Labill.
Asclepiadaceae: *Cryptostegia madagascariensis* Hemsl.
Bignoniaceae: *Kigelia aethiopica* var. *borneensis* Sprague, *Parmentiera edulis* DC., *Tabebuia haemantha* (Bert.) DC.
Bixaceae: *Cochlospermum* sp., *Oncoba echinata* Oliver
Bombacaceae: *Ochroma pyramidale* (Cav.) Urban
Boraginaceae: *Cordia glabra* L., *Cordia* sp., *Ehretia buxifolia* Roxb.
Casuarinaceae: *Casuarina equisetifolia* L.
Compositae: *Lactuca intybacea* Jacq.
Dilleniaceae: *Dillenia indica* L.
Euphorbiaceae: *Aleurites moluccana* (L.) Willd., *Antidesma bunius* (L.) Spreng., *Drypetes glauca* Vahl, *Garcia nutans* Rohr, *Manihot glaziovii* Muell. Arg.
Guttiferae: *Clusia rosea* Jacq., *Clusia* sp., *Mammea americana* L.
Labiatae: *Scutellaria ventenatii* Hook.
Leguminosae: *Aeschynomene americana* L., *Bauhinia aculeata* L., *Bauhinia acuminata* L., *Bauhinia candicans* Benth., *Bauhinia monandra* Kurz., *Bauhinia pauletia* Pers., *Bauhinia purpurea* L., *Bauhinia reticulata* DC., *Bauhinia retusa* Roxb., *Bauhinia rufescens* Lam., *Bauhinia tomentosa* L., *Bauhinia triandra* Roxb., *Bauhinia variegata* L., *Bauhinia* sp., *Caesalpinia coriaria* (Jacq.) Willd., *Caesalpinia punctata* Willd., *Caesalpinia sappan L.*, *Cajanus cajan* (L.) Druce, *Calopogonium mucunoides* Desv., *Cassia alata* L., *Cassia corymbosa* Lam., *Cassia fistula* L., *Cassia multijuga* Rich., *Cassia occidentalis* L., *Cassia spectabilis* DC., *Cassia* sp., *Cassia* sp., *Centrosema pubescens* Benth., *Cicer arietinum* L., *Crotalaria alata* Buch.-Ham. ex Roxb., *Crotalaria grantiana* Harv., *Crotalaria incana* L., *Crotalaria intermedia* Kotschy, *Crotalaria lanceolata* E. Mey., *Crotalaria* maxillaris Klotzsch, *Crotalaria paulina* Schrank, *Crotalaria retusa* L., *Crotalaria spectabilis* Roth, *Crotalaria usaramoensis* E. Baker, *Crotalaria vitellina* Ker-Gawl., *Crotalaria* sp., *Dalbergia sissoo* Roxb., *Delonix regia* (Bojer) Raf., *Desmodium cajanifolium* (HBK.) DC., *Desmodium cinereum* (HBK.) DC., *Desmodium discolor* Vog., *Desmodium gyrans* (L.) DC., *Desmodium gyroides* (Roxb.) DC., *Desmodium nicaraguense* Oerst. ex Benth., *Desmodium canum* (Gmel.) Schinz & Thellung, *Desmodium umbellatum* (L.) DC., *Desmodium uncinatum* (Jacq.) DC., *Desmodium* sp., *Dolichos falcatus* Klein ex Willd., *Dolichos* sp., *Gliricidia sepium* (Jacq.) Steud., *Glycine max* (L.) Merr., *Indigofera arrecta* Hochst., *Indigofera cordifolia* Heyne ex Benth., *Indigofera cytisoides* L., *Indigofera endecaphylla* Jacq., *Indigofera glandulosa* Willd., *Indigofera hirsuta* L., *Indigofera linifolia* Retz., *Indigofera mucronata* Spreng., *Indigofera pilosa* Poir., *Indigofera suffruticosa* Mill., *Indigofera sumatrana* Gaertn., *Indigofera teysmanni* Miq., *Indigofera* sp., *Leucaena glauca* (L.) Benth., *Lotus corniculatus* L., *Lupinus angustifolius* L., *Macroptilium lathyroides* (L.) Urban, *Medicago sativa* L., *Medicago* sp., *Melilotus alba* Desv., *Mimosa* sp., *Mucuna pruriens* (L.) DC., *Pachyrhizus erosa* (L) Urban, *Peltophorum* sp., *Phaseolus aureus* Roxb., *Phaseolus calcaratus* Roxb., *Phaseolus* sp., *Poinciana pulcherrima* L., *Pongamia pinnata* (L.) Merr., *Pueraria lobata* (Willd.) Ohwi, *Pueraria phaseoloides* (Roxb.) Benth., *Sabinea* sp., *Stizolobium aterrimum* Piper & Tracy, *Stizolobium deeringianum* Bort., *Stizolobium* sp., *Stylosanthes bojeri* Vog., *Stylosanthes gracilis* HBK., *Sutherlandia frutescens* R. Br., *Swartzia grandiflora* Willd., *Tephrosia candida* DC., *Tephrosia noctiflora* Boj., *Tephrosia sinapou* (Buc'hoz) A Chev., *Tephrosia villosa* Pers., *Tephrosia vogelii* Hook. f., *Teramnus volubilis* Sw., *Trifolium campestre* Schreb., *Trifolium incarnatum* L., *Trifolium mexicanum* Hemsl., *Trifolium repens* L., *Trifolium xerocephalum* Fenzl, *Trifolium* sp., *Vicia obscura* Vog., *Vigna luteola* (Jacq.) Benth., *Vigna marina* (Burm.) Merrill, *Vigna sinensis* (Torn.) Savi, *Vigna vexillata* (L.) A. Rich., *Vigna* sp.
Liliaceae: *Chlorophytum* sp.
Lythraceae: *Punica granatum* L.
Malpighiaceae: *Byrsonima* sp., *Malpighia punicifolia* L.

Malvaceae: *Hibiscus cannabinus* L., *Hibiscus mutabilis* L., *Hibiscus sabdariffa* L.
Moringaceae: *Moringa* sp.
Musaceae: *Heliconia bihai* L., *Heliconia latispatha* Benth., *Musa* sp.
Myrtaceae: *Couroupita guianensis* Aubl., *Psidium guajava* L., *Psidium littorale* Raddi, *Psidium microphyllum* Britton
Orchidaceae: *Oncidium* sp.
Palmae: *Arecastrum romanzoffianum* (Cham.) Beccari, *Elaeis guineensis* Jacq., *Euterpe globosa* Gaertn., *Pritchardia pacifica* Seem. & Wendl., *Sabal* sp.
Piperaceae: *Piper nigrum* L.
Passifloraceae: *Passiflora edulis* Sims
Rhamnaceae: *Zizyphus mauritiana* Lam.
Rosaceae: *Chrysobalanus icaco* L., *Rubus rosaefolius* Smith
Rubiaceae: *Genipa americana* L., *Psychotria* sp.
Sapindaceae: *Sapindus* sp.
Sapotaceae: *Chrysophyllum cainito* L., *Chrysophyllum oliviforme* L., *Chrysophyllum* sp.
Solanaceae: *Cestrum* sp., *Cyphomandra betacea* (Cav.) Sendtn., *Solanum auriculatum* Ait., *Solanum aviculare* Forst., *Solanum marginatum* L.
Sterculiaceae: *Guazuma ulmifolia* Lam., *Kleinhovia hospita* L., *Sterculia foetida* L.
Taccaceae: *Tacca* sp.
Taxaceae: *Podocarpus coriacea* L. C. Rich.
Urticaceae: *Boehmeria nivea* (L.) Gaud.
Verbenaceae: *Clerodendrum speciosissimum* Paxt., *Stachytarpheta jamaicensis* (L.) Vahl, *Vitex divaricata* Sw.
Zingiberaceae: *Aframomum melegueta* (Rosc.) K. Schum.

## Discussion and Summary

Among 311 species of plants tested for agglutinating activity with human red blood cells, seed extracts of 45 showed some degree of specificity for blood of particular types. Extracts of others were nonspecific, hemolytic, or gave no reaction. Among those tested, *Bauhinia variegata* L. seems promising as a source of naturally occurring anti-N agglutinin or lectin. The high anti-$A_1$ activity of *Dolichos biflorus* L. was confirmed. While several other species gave specific reactions, the agglutination was so weak that they will probably be of theoretical interest only.

On the basis of this work, it appears that a continuing screening program could be expected to uncover new and perhaps better plant sources of blood typing reagents. It also appears worthwhile to explore the possibility of commercial production of some of the more promising species.

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# Guar, A Summer Row Crop for the Southwest

*Guar, with a 50-year crop history slowly establishes its agronomic and economic merit. Guar is now in USDA's "new crops" program, among crops that are substitutable in land use and income yield for surplus crops.*

*Guar has 4 virtues. It is (1) an annual crop, (2) a leguminous plant, (3) adapted to mechanical planting, cultivation, and harvesting, and (4) the gum made from it goes to an industrial market. Only a part of this market is supplied now, and the potential usage could be upped several-fold.*

FREDERICK J. POATS[1]

## History

Guar *(Cyamopsis tetragonoloba)* was introduced into the United States, from India, about 1906. It was hoped that it would become established as a desirable forage-producing crop in the irrigated land areas of the Southwest. Later, interest in its culture as a domestic source of guar beans to make guar flour and gum to reduce dependence upon foreign sources of guar and locust bean (*Ceratonia siligua*) gums supported development.

Guar was first produced on irrigated lands in New Mexico and Arizona. The imported strains, particularly a forerunner of the Mesa type, were used in these attempts to produce a guar crop at a profit. These efforts were unsuccessful, and for a time, there were no further attempts to introduce guar as a crop.

During World War II, there was a scarcity of all imported vegetable gums, guar gum, and locust bean gum among them. With this scarcity, there was renewed interest in growing guar in the irrigated lands of New Mexico and Arizona. This time, new strains with higher yields of seed, one with a branched stalk, and another requiring a shorter growing season were found. Seed for developing crops of these desirable strains were obtained by rogueing plants in the fields. For the war period, guar beans were grown on irrigated land and made into gum at a processing plant located in the growing area. Following the war, interest in growing guar on irrigated land died out again. It was now without the benefits of contracted acreage payments and other crop guarantees from the processor that had existed during the war.

This second round of interest, with the improvements derived from strains selected, gave guar a new "toehold" for establishment as an economically-justified crop. It is the nature of this multifunctional character that gives guar such an interesting and challenging potential as a domestic crop today.

## Modern Guar Crop Developments

**Gum Scarcity in War.** Near the close of World War II flax growers in southeastern Texas, in the area southeast of San Antonio, tried guar as a summer legume to follow early harvested flax. Producers were successful enough with crop yields to persuade a processor to establish a small bean processing facility at Kenedy, Texas.

Growing of guar for beans was now rid of the onus of costs for irrigated culture and a single crop value base. It was now grown as a multi-purpose crop for nitrogen fixation and humus producing effects, as well as for beans.

However, production and harvesting difficulties continued to plague guar's ready acceptance in its expanded role.

[1]U.S. Department of Agriculture, Agricultural Marketing Service, Washington 25, D. C.

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Fig. 1. The Groehler variety of guar. Note the pods in various stage of maturity and the basal branching character of the stalk. The latter is a typical feature of this widely planted guar variety.

Fall rains frequently came before the beans could be harvested, and the moisture-blackened seed could not be used for making into a usable gum. Using rain-damaged seed for feed gave a return little more than sufficient to pay the harvesting and milling costs. Also, guar planting, following the flax harvest from the fields, was too late for good moisture conditions for germination and vigorous plant formation before the onset of dry hot days of midsummer.

These conditions have limited the development and expansion of production of guar in the area. Today it continues to be a summer legume crop in the flax producing area, but interest in it as a cash crop through sales of seed for making gum is believed to be in decline.

Almost simultaneously with the introduction of guar crop production in southeastern Texas, another successful introduction of guar was achieved in an area farther west. This was in the dry-farming lands of northwestern Texas and southwestern Oklahoma. The center of this latest domestic guar crop development is Wilbarger County, Texas. Here, where annual rainfall averages less than 35 inches a year, and the predominant soil types are deep sands and sandy loams, the adaptation of guar was initiated by several progressive farm operators. The establishment of guar as a regularly planted crop in the area was due to a number of characteristics of the plant, its culture, and the fact that it fit into the crop needs of the area. It is not possible to distinguish the one characteristic of guar that led to its establishment and continued expansion in the area. Analysis of economic and cultural factors indicate that the combination of characteristics guar offered provided the conditions for its acceptance rather than any one element or factor.

**Renewed Federal and State Interest in Guar.** The U.S. Department of Agriculture and agricultural agencies in the States of Texas and Oklahoma have increased their interest in guar as a potentially expanding acreage crop.

At the Federal level, guar has been named among crops to be given consideration as alternative or supplementary crops to those now produced in surplus of market requirements. Guar fits this list from several bases of judgment. It is (1) an annual row crop, (2) a plant that is valuable for its nitrogen fixing characteristic, (3) adapted to mechanical planting, cultivation and harvesting, and (4) the major cash value product, the gum, goes to an expanding industrial, non-food-use market.

At the State level guar fits into a program that seeks development of crops that offer advantages in soil conservation, complementary returns to crops now grown, and greater efficiency in use of facilities of production by the farmers in the State.

**The Domestic Producers, A Focal Point for Economic Evaluation of Guar Crop Production.** Economic study of guar as a new crop began with a study of grower economics at Kenedy, Texas and Wilbarger County, Texas.

From knowledge obtained first hand by talking with producers, the county agent and the soil conservationist of Wilbarger County, and those whose business is affected by guar production, a banker, cotton gin operators, an alfalfa dehydrator, and a grain elevator operator, much can be told about guar, its usefulness, how its fits into the crop program, and its developmental needs and potentials as a modern agricultural crop.

**Guar Crop Research by Texas Agricultural Experiment Station.** At the Iowa Park Experiment Station, Iowa Park, Texas, agronomic development and varietal testing of guar is under way. There, guar is liked as a dual purpose summer legume. It is drought resistant, resistant to cotton root rot and other common plant diseases, gives high yields

of forage and seed, increases yields of crops following it in rotation, and furnishes valuable livestock feed, either as a silage crop or from its seed. Its seed are sold for feed and industrial uses and do not compete in food crops markets. Planting, cultivation, and harvesting are done by conventional machinery already used in the area on other crops.

**Growers Give Their Reasons for Liking Guar.** Producers in the farm area around Vernon, Texas, echoed these Experiment Station findings and added a few of their own. As a row crop legume in rotation with cotton, guar is "tops" for the area. It was reported to have doubled yields per acre of cotton on one farm. Cotton fiber quality is also improved through guar and cotton crop rotation. Where guar and cotton have been rotated successively for a number of years, six in one case, cotton yields have continued to improve, but never so dramatically as the first year following a guar crop in rotation.

**Crop Rotation Emphasizes Guar's Benefits.** Guar puts a lot of below-ground humus in the sandy soils, as well as the nitrogen fixed in the nodules on the roots. The deep-set, quickly decomposed guar root system provides moisture-conserving humus for the next year's crop. During the growing period, guar's leafy branched stems shade the middles, helping to conserve moisture, as well as reducing wind erosion.

**Labor and Equipment Use is Complementary.** Guar does not compete with planting or harvest time of other crops. It is planted in early May and harvested for seed after middle of September. Seed can be stored in any dry shelter. Rats and weevils do not bother it and the seed seems to germinate well, even after 2 or 3 years of such storage.

**Costs and Dividends for Guar Production.** Guar economics, from the producers' viewpoint, are good. Its growth-stimulus effect on succeeding crops pays planting and cultivation costs, even if the seed crop is lost to moisture from early fall rains. Harvest, storage, and grinding costs are 1 to 2 cents a pound, the price of beans that are rain damaged and suited only for livestock feed. (They are usually rolled and fed in a mixed feed with rolled feed grains.) If bright seed are obtained (when no rain damage occurs) then the price paid for gum processing uses is an extra bonus. Farmers get 3 to 3.5 cents a pound for bright seed sold to dealers in the Vernon area. Yields vary from 500 to over 1,000 pounds of seed harvested per acre.

On account of the usage or market choices for guar seed described, one grower in the Vernon area says that farmers never really lose money when they plant guar. At each stage of cost increase for the crop, such as harvesting, these added costs can be charged to added revenue obtained, and a decision can be made whether or not to proceed. Prior to the harvesting operations, all costs of guar production, i.e., tillage, seeding (5 to 6 lbs. of seed per acre) and cultivation are easily regained in the soil building and nitrogen fixing benefits of guar. Harvesting costs are the first costs of guar production which should logically be charged to income from sale of seed.

**The Future For Guar Crop Production**

**Problems to be Resolved.** What then, are the problems associated with growing more domestic supplies of guar seed for making gum? Our present domestic market for gum is about 17 million pounds a year, less than one-tenth of which is supplied by domestic producers.

First in the problems cited by producers was need for a local processing plant as a market for seed, with a known annual demand for processable seed. A receiving and processing facility that was local to this producing area would definitely stimulate production, according to those producers visited. Producers

knew that the price of processable beans was competitive with foreign beans (from India and Pakistan primarily) and that expanded production would continue to face this competition.

Second, guar fits into the crop program of the area on the light sandy soils where dry-farming methods are used. Its cash crop returns will not equal the costs of irrigation, nor costs of hoeing and weeding. Expansion of production would probably be limited to areas having this soil type and where dry farming methods are used for row crops. Guar fits into the crops rotation as a summer row crop legume. It would not expand, on account of the economics of production, yields, and cash returns, into irrigated farming areas to a large degree.

Third, a glabrous-leaved (without hairy surface) guar plant would reduce the amount of guar leaf trash in cotton, when cotton is inter-row rotated with guar. Such a variety is now under development at the Texas Agricultural Experiment Station at Iowa Park, Texas.

Fourth, grades and standards for guar seed, according to the uses to which they are suited, need to be developed. A set of commercial grades is already in existence. They are not widely accepted or used, however, except for beans shipped to the gum processing plant in southeast Texas.

Fifth, work needs to be done to achieve methods of earlier harvesting. Since seed mature through much of the growing season of the plant, an earlier harvest would save from fall rains and moisture damage a larger proportion of total seed produced by the plants. A method of separating mature and immature seed collected in early harvesting operations would improve producers' prospects for making some harvest of bright seed each year.

Sixth, as an alternative to the above approach, development of a strain of guar that is either (a) more tolerant of moisture at maturity, or (b) had a shorter growing season requirement for maturation would reduce some risks of seed loss, and thereby enhance returns from guar as a supplemental cash crop.

Seventh, whole guar beans have been successfully used in a rolled feed for livestock. The beans contain 21 percent protein. Feed use possibilities for moisture-damaged seed needs to be more thoroughly examined. Animal nutrition benefits and market considerations should be a part of such an evaluation of potentials.

**Domestic Acreage Requirements.** The potential growing area for guar is a large dry farming area from southwestern Kansas, south to central and southwest Texas, wherever light sandy soils, a 125 day growing season, and annual row crops production occurs. Assuming an average seed yield of 600 lbs. per acre, yielding 200 lbs. of processed gum, 85,000 harvested acres would supply current domestic guar gum processing needs. At present, 20,000 to 30,000 acres are planted with a guar crop. Most of the acreage produced each year is grazed in the field, harvested for seed to use the following year, or made into livestock feed. Beans offered and sold for processing into gum have not exceeded one-half of the total production. Increased acreage is needed, therefore, to satisfy domestic markets for guar gum and provide production over a wider geographic area to reduce possibility of total crop losses in poor seasons.

Guar's greatest asset is its capacity to fix nitrogen. This one characteristic is believed sufficient by those now growing it to encourage others to plant it. There are indications from industrial applications research that guar gum uses can be greatly expanded through a program of searching and development of new uses and expansion of existing uses.

Industrial uses in food, paper, mining, textiles, and explosives would provide

a market potential for guar gum of 100 million pounds a year. In some of these applications guar gum acts as an ingredient, being a binder and a jelling agent. In others it acts as a dispersant or flocculating agent to aid in processing of products. If all applications known to be feasible could be fully exploited, a market of this size would require about a half million acres just to produce beans for processing. Economic evaluations of industrial market opportunities for guar gum now being conducted will show the extent to which these potential market volumes may be profitable and achievable. All economic factors, viewed from the production area, point toward more production and expansion of areas where guar is grown as an annual row crop legume in the southern Great Plains area.

# Antibiotic Activity of an Extract of Peyote (Lophophora Williamii (Lemaire) Coulter)[1]

JAMES A. McCLEARY,[2] PAUL S. SYPHERD,[3] and DAVID L. WALKINGTON[3]

Attempts to obtain antibiotics from diverse groups of plants have been numerous. These attempts have included such varied taxa as bacteria, lichens, mosses (1) and flowering plants (2).

The Arizona State Department of Liquor Control recently confiscated several sacks of peyote, *Lophophora williamsii* (Lemaire) Coulter, and turned a number of the plants over to the authors for research purposes.

The use of peyote in religious rites by many Indian tribes is common knowledge (3). In addition, curative properties for such varied ailments as toothache, pain in childbirth, fever, breast pain, skin diseases, rheumatism, diabetes, colds, and blindness, among other things, have been claimed for this plant by the same peoples (4). It is listed in the *Farmocopia Mexicana* where incorporation of the name into a native term, the verb "empeyotizarse," meaning self medication for the relief of a hangover after over indulgence in alcoholic beverages, is reported (5). The *U. S. Dispensatory* (6) lists peyote under the name *Anhalonium* and indicates its use to some extent in various forms of neurasthenia and hysteria and also in cases of asthma.

The alkaloid composition of this plant has been intensively studied (7). However, peyote is often listed under a synonym, *Anhalonium*, as *Anhalonium williamsii* or *Anhalonium lewinii*. In addition, the common name is also applied to plants which taxonomists place in different genera such as *Ariocarpus, Astrophytum, Pelecyphora, Strombojormis, Aztekium, Obregonia, Dolichothele,* and *Solisia,* so that some question may be raised as to the validity of many reports (8).

## Methods

Extracts of whole peyote plants were prepared in various solvents and screened for antimicrobial activity. Ninety-five % ethanol yielded an extract exhibiting the best inhibition against bacterial growth. A 25% mixture (w/v) of plant material to ethanol was macerated for 15 minutes in a Waring blendor and filtered through coarse filter paper in a Buchner funnel to remove the dense pulp. Precipitation of water-insoluble material occurred following removal of the ethanol *in vacuo* in a 60° C water bath. A volume of distilled water equal to the volume of liquid remaining in the flask was then added and the precipitate removed by filtration. This crude supernatant was tested for antibiotic activity and showed positive microbial inhibition.

In an attempt to remove the organic acids and alkaloids, the following technic was employed. The supernatant was adjusted to pH 2 with 1 M HCl and maintained at 5° C for 24 hours during which time a fine precipitate developed. The material was filtered, the supernatant adjusted to pH 12 with 1 N NaOH, refrigerated for 24 hours, and a second precipitate removed by filtration. All precipitates, including the one recovered

[1]Supported in part by a grant from the National Institute of Allergy and Infectious Diseases, U. S. Public Health Service.

[2]Dept. of Botany, Arizona State University, Tempe. Present addr.: Orange County State College, Fullerton, Calif.

[3]Dept. of Bacteriology, University of Arizona, Tucson, Arizona. Present addr.: Yale Univ., New Haven, Conn.

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from *in vacuo* evaporation, were redissolved, adjusted to pH 7 and tested for antibiosis. The supernatant at this point was dark yellow and, in an attempt to remove the color, the extract was adjusted to pH 7, adsorbed with activated charcoal and filtered with the aid of Celite. The remaining colorless supernatant was evaporated to dryness, leaving a crystalline residue. The residue was dissolved by shaking for 2 hours in purified absolute methanol. Insoluble contaminating salts were removed by filtration and the supernatant methanol extract was evaporated to dryness. The crystalline substance obtained in this manner was considered to contain the principal active antibiotic substance and was given the name *Peyocactin*. The crystals were then dissolved in distilled water, adjusted to pH 7, and tested for antibiosis.

### Antimicrobial Assay

Antibiotic activity was determined by placing 0.05 ml of the extract in Oxford cups set in Petri dishes containing 12 ml of Penassay Agar (Difco) seeded with 0.1 ml of a 24-hour broth culture of the test organisms (9, 10). The test organisms used in screening the peyocactin and the other extracts included *Staphylococcus aureus* (USDA 209), *Sarcina lutea* (USDA 1001), *Bacillus subtilis* (USDA 220), *Neisseria catarrhalis*, and *Escherichia coli* (ATCC 8677). The seeded plates were usually incubated for 18 hours and presence or absence of zones of inhibition recorded. Plates inoculated with enteric bacteria were read after only 12 hours of incubation. In an effort to obtain a more nearly complete antimicrobial spectrum of the peyocactin, numerous other bacteria and one pathogenic fungus were tested using the method described above (Table 1).

In each test, controls of physiological saline and the crude extract from which ethanol and precipitates had been removed were used. Because of the high level of activity exhibited by peyocactin against *S. aureus*, 18 penicillin-resistant strains of this organism were obtained and tested. All of the strains tested were found to be inhibited by peyocactin to approximately the same degree as the *S. aureus* (USDA 209) originally used. Ten of the resistant strains of *S. aureus* were known phage types[4] and the other 8 were coagulase positive and mannitol positive strains isolated from patients.[5]

[4]Kindly supplied by Dr. Griffith, V. A. Staphylococcus Ref. Lab., Batavia, N. Y.
[5]Tucson General Hosp., Tucson, Ariz.

TABLE I
RESULTS OF ANTIMICROBIAL ASSAY OF PEYOCACTIN

| Organism | Activity of* Peyocactin | Organism | Activity of* Peyocactin |
|---|---|---|---|
| *Agrobacterium tumefaciens* | ++ | *Proteus vulgaris* | 0 |
| *Bacillus cereus* | ++ | *Pseudomonas aeruginosa* | 0 |
| *B. subtilis* (USDA 220) | +++ | *Salmonella pullorum* | 0 |
| *Diplococcus pneumoniae* | 0 | *S. typhimurium* | 0 |
| *Escherichia coli* (ATCC 8677) | +++ | *Sarcina lutea* (USDA 1001) | ++++ |
| *Klebsiella pneumoniae* | 0 | *Shigella flexneri* | ++ |
| *Micrococcus flavus* | +++ | *Staphylococcus aureus* (USDA 209) | +++ |
| *M. rubens* | +++ | *S. epidermitis* | +++ |
| *Mycobacterium phlei* | ++ | *Streptococcus pyogenes* | ++++ |
| *Neisseria catarrhalis* | +++ | *S. salivaris* | +++ |
| *Phytomonas campestris* | +++ | *Candida albicans* | + |

* 0 — no activity noted
\+ — zone of inhibition only under Oxford cup
++ — idem. 8 to 10 mm diameter
+++ — idem. 11 to 15 mm diameter
++++ — idem. larger than 15 mm diameter

### *In Vivo* Studies

Swiss-Webster white mice were used for preliminary animal toxicity tests and protection studies to indicate the degree of inhibitory action of peyocactin against fatal staphylococcal infection. In every case the protected animals survived while those in the control group succumbed within 60 hours after infection with *S. aureus*.[6]

### Discussion

Results of *in vitro* studies with the ethanol extract of peyote indicate the presence of an antimicrobial agent. Attempts to purify this ethanol extract have resulted in the isolation of an unidentified substance appearing as amorphous crystals after evaporation of the methanol. The crystals are very soluble in water and other polar solvents. In spite of its solubility in water, however, the antimicrobial agent cannot be separated from the plant material by simple water extraction. Methanol acts as an effective solvent, showing little difference in the final activity from that of the ethanol extract. Peyocactin exhibits no solubility in hexane or other non-polar solvents.

Limited animal studies were performed with dissolved peyocactin so that an indication of toxicity and possible *in vivo* usefulness might be obtained. The material injected into the peritoneal cavity of mice was shown to be toxic in certain concentrations, but because different batches of the extract showed differing ranges of toxicity and antimicrobial activity, the toxicity could not be expressed in weight/volume relationship. Levels of non-toxic administrations were found that would protect mice against staphylococcal infection fatal to control mice. These results are considered to be only a presumptive preliminary study. With successful isolation of peyocactin in pure form, complete toxicity and *in vivo* protection studies will be undertaken.

[6]We appreciate the assistance of Dr. Kenneth F. Wertman, other members of Dept. of Bacteriology, and Univ. of Arizona for facilities and mice to carry on these preliminary tests.

### Summary

A water-soluble crystalline substance, separated from an ethanol extract of *Lophophora williamsii* (Lemaire) Coulter, exhibited antibiotic activity against a wide spectrum of bacteria and a species of the imperfect fungi. The name peyocactin has been given to the principal antimicrobial component contained in this partially purified substance. Of particular interest was its inhibitory action against 18 strains of penicillin-resistant *Staphylococcus aureus*. Preliminary protection studies with mice suggest the *in vivo* effectiveness of peyocactin.

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# BOOK REVIEWS

**Africa—Its People and Their Culture History.** George Peter Murdock. McGraw-Hill Book Company, Inc., New York-Toronto-London. 1959. xiii + 456 pp. 17 maps (including a large one in a pocket on the back cover). $8.75, text edition; $11.75, trade edition.

Professor Murdock's new book points the way to one of our greatest opportunities in Economic Botany, the collection, interpretation, and uses of the cultivated plants of Africa. Before the publication of this bird's-eye view of around 5000 African tribes and sub-tribes, such a problem could only be worked at piecemeal. Fortunately for ethnobotanists "food producing activities" were one of the activities which came within the scope of Murdock's survey, along with (1) kinship and marriage, (2) division of labor by sex, (3) housing patterns, and (4) social organization. To have included the entire continent of Africa in his net and to have gone through a miscellaneous literature in four languages was a herculean task. He tells us in his introduction that he "early discovered the virtual absence of reliable guides to a preliminary orientation" but goes on to pay heartfelt tributes to his few predecessors.

If Africa was outstandingly poor in any generalizing literature, Murdock found it outstandingly rich in descriptive works both as to quantity and to quality. Out of this vast sifting has come a volume of 456 pages which will be an eye-opener to most students of cultivated plants.

The time span considered is from Neolithic agricultural times (roughly 5000 B.C.) to the end of colonial penetration about 1900 A.D. Its first forty pages are given over to orienting chapters on geography, race, language, economy, society, government, and history. The rest of the book groups all the tribes in 10 parts under such natural headings as African hunters, Sudanic agricultural civilization, Expansion of the Bantu, Eastern African pastoralism.

Two of the chapters will be of outstanding interest to students of economic plants. Murdock presents strong evidence for an independent origin of agriculture in Africa, an agriculture which spread early to India, reaching Egypt (if at all) only in much later times. There is a little general discussion of the evidence in the introductory chapter on Economy and well organized presentations in the chapters on "Nuclear Mande" (Western Sudan) and "Central Ethiopians." For each of these groups he presents such interesting lists of cultivated plants of presumably African origin that they are worth quoting in full to a botanical audience.

WESTERN SUDAN

CEREAL GRAINS[1]

Fonio, acha grass, or hungry rice (*Digitaria exilis*). Continuously distributed from Senegal to Northern Cameroon, often as a staple, this grain has not diffused to other regions of Africa or the world.

Pearl millet, or bulrush millet (*Penniesetum spicatum* or *P. typhoideum*). A staple throughout most of Negro Africa, this cereal has also spread to India and elsewhere.

Sorghum (*Sorghum vulgare*, formerly *Andropogon sorghum*). Of its numerous varieties three are especially important in its West African center of origin: dry-season corn (var. *cernuum*), feterita (var. *caudatum*), and Guinea corn (var. *guineense*).

LEGUMES

Cow pea (*Vigna unguiculata* or *V. sinensis*). Widespread in Negro Africa, whence it spread at an early date to India.

TUBERS AND ROOT CROPS

Coleus, or Kafir potato (*Coleus dazo* and *C. dysentericus*). Common in the southern Sudan and adjacent areas, whence it was early carried to India.

Earth pea, or Bambara groundnut (*Voandezia subterranea* formerly *Glycine subterranea*). This plant, whose habit of growth resembles that of the American peanut, is widely distributed in Africa.

[1] A fourth indigenous Sudanic cereal, African rice (*Oryza glaberrima*), was brought to the author's attention while the book was in press.

Geocarpa bean, or geocarpa groundnut (*Kerstingiella geocarpa*). This plant, which is somewhat similar to the peanut and the earth pea, is confined to the western Sudan.

Guinea yam (*Dioscorea cayenensis* and *D. rotundata*). A native of the Guinea coast, this root crop extends into adjacent southern Sudan.

Rizga (*Plectranthus floribundus*). This cultigen is confined mainly to Northern Nigeria and immediately adjacent regions.

Yam bean (*Sphenostylis stenocarpa*). This plant, which is grown for its seeds as well as for its tuber (reported to taste like a potato), has a modest distribution in west and central Africa.

LEAF AND STALK VEGETABLES

Okra, or gumbo (*Hibiscus esculentus*). Widespread in Africa and today also in the New World.

VINE AND GROUND FRUITS

Fluted pumpkin (*Telfairia occidentalis*). Confined mainly to West Africa.

Gourd, bottle gourd, or calabash (*Lagenaria vulgaris*). This plant was cultivated in pre-columbian times in both the Old and the New World, and its present distribution is practically universal. Most authorities agree that the Old World gourds were first domesticated in the western Sudan, whence they spread to Egypt during the second millennium B.C., and also at a very early date to India.

Watermelon (*Citrullus vulgaris*). It is used in Africa not only for its fruit but also for the oil extracted from its seeds. It spread from the Sudan to Egypt in the second millennium B.C. and has today a nearly universal distribution.

Yergan, or egusi (*Cucumeropsis edulis* and *C. mannii*). This squashlike ground fruit is confined mainly to West Africa.

TREE FRUITS

Akee, or akee apple (*Blighia sapida*). This fruit tree, native of West Africa, was carried to the New World during the slave trade.

Tamarind (*Tamarindus indica*). Probably Sudanic in origin, this tree spread both to Egypt and to India at an early date.

CONDIMENTS AND INDULGENTS

Kola (*Cola acuminata* and *C. nitida*). This tree, sometimes cultivated but more often protected in its wild state, is a native of the western Sudan.

Roselle, or red sorrel (*Hibiscus sabdariffa*). Widespread in Africa, whence it has spread to India and the New World.

TEXTILE PLANTS

Ambary, or hemp-leafed hibiscus (*Hibiscus cannabinus*). Widespread in the Sudan and sporadic in East Africa.

Cotton (*Gossypium herbaceum*). Originally ennobled in the western Sudan from the indigenous wild *G. anomalum*.

OIL PLANTS

Oil palm (*Elaeis guineensis*). Widespread in tropical West Africa.

Sesame, benniseed, or gingelly (*Sesamum indicum*). Widespread in Africa, this plant spread to India at a very early date, and thence to Mesopotamia, but it was not adopted in Egypt until the Greco Roman period.

Shea tree, or shea-butter tree (*Butyrospermum parkii*). The nuts of this tree, which grows semiwild and is only occasionally fully cultivated, provide an important source of fat in the zone north of the habitat of the oil palm.

ETHIOPIA

CEREAL GRAINS

Eleusine, or finger millet, or ragi (*Eleusine coracana*). This cultigen spread early to India, as well as widely in East and South Africa.

Teff (*Eragrostis abyssinica*). This cereal has spread to a very limited extent into the eastern Sudan.

ROOT CROPS

Ensete, or the Abyssinia banana (*Ensete edulis*, formerly *Musa ensete*). This plant, used for its edible roots rather than its fruits, was first domesticated in southwestern Ethiopia, where it is still the staple crop.

LEAF AND STALK VEGETABLES

Cress, or garden cress (*Lepidium sativum*). This plant is also used for the oil expressed from its seeds.

CONDIMENTS AND INDULGENTS

Coffee (*Coffea arabica*).
Fenugreek (*Trigonella foenum-graecum*).
Kat, or Arab tea (*Catha edulis*).
Vegetable mustard (*Brassica carinata*).

OIL AND DYE PLANTS

Castor (*Ricinus communis*). This oil plant spread to Egypt early in the Dynastic period.

Remtil, or nug (*Guizotia abyssinica*). An important oil plant.

Safflower (*Carthamus tinctorius*). This plant, used both as a dye and for oil, spread to Egypt about 1500 B.C.

In introducing the discussion of the Sudanic complex, Murdock makes a strong case for an early independent origin of Agriculture in almost exactly the same region selected by the reviewer on wholly different evidence (Anderson in press, Darwin Cen-

tennial Volumes). He points out that the failure to recognize this important center is due to the fact that botanists who had been long aware of the African origin of certain crops were without linguistic or ethnographic surveys which would help in localizing such a center. Moreover there had been an unfortunate "paucity of research in precisely the most crucial areas." Vavilov, furthermore, though he reached all the other centers of origin (or survival, to be more precise) never visited Negro Africa, and only reached the edge of the problem in Ethiopia. Murdock points out that the world's agricultural innovators "have belonged to four distinct races. Along with the caucasoids who developed the Southwest Asian complex, the Mongoloids who achieved the Southeast Asian complex, and the American Indians who elaborated the Middle American complex, we must now align the West African Negroes as one of mankind's leading creative benefactors."

Those who consult the volume in a hurry will be frustrated by the lack of a general index or a general bibliography. A little study shows that the book's organization made selected bibliographies for the separate chapters a more convenient arrangement. As for an index, there *is* one for tribal names and it alone runs into thirty pages of four columns each! When one has used the book for a time, its logical organization becomes an adequate substitute.

Murdock's "Africa" spans so many fields and integrates so many details, that an authoritative and comprehensive review would have to be delegated to a committee of experts. For Ethiopia, the only part of Africa with which I am personally familiar, I have no corrections for any of his statements, and the addition of further evidence (as for instance the probable center of origin of tetraploid coffees) would only strengthen his thesis. I can only echo the words which a distinguished Africanist to whom I lent my pre-publication copy, wrote on the fly leaf, "Returned with thanks. A remarkably adequate attempt to do the impossible."

EDGAR ANDERSON
*Missouri Botanical Garden*

**Cellulose Pulp and Allied Products.** Julius Grant. i-xvi & 512 pp., 75 figs. Interscience Publishers, Inc. New York. 1959. $8.50.

"Cellulose Pulp and Allied Products," written by a British chemical consultant, is a third edition of that published in 1938 as "Wood Pulp" and revised in 1947 as "Wood Pulp and Allied Products." The present title reflects the author's attention to the manufacture of pulp from raw materials other than wood and to the by-products of pulp manufacture.

Like other works dealing with the general field of pulp and paper technology, "Cellulose Pulp and Allied Products" devotes chapters to history of pulp and paper making, chemical and physical properties of cellulose, identification and physical and chemical evaluation of woods and other raw materials, collection and preparation of raw material, description of pulping processes in current use, bleaching of pulp, and processing of pulp for the manufacture of paper. Additional chapters are devoted to such timely subjects as the by-products of woodpulping processes, preparation of pulp from hardwoods and "semi-tropical" conifers, and production of pulp from non-woody fibrous raw materials.

The author's discussion of "By-products from Wood and Other Pulping Processes" will be of special interest to economic botanists. This chapter reëmphasizes that "cellulose is the central figure of a system of which paper is only one of the many (though one of the most important) members." It discusses the preparation of charcoal, the preparation and uses of wood flour, the saccharification of cellulose, the utilization of spent sulfite liquor for manufacture of the food yeast *Torula,* the production of tall oil from alkaline cooking liquors, and so forth.

The chapter devoted to "Cellulose Pulp from Vegetable Materials Other Than Wood" will prove somewhat disappointing to the reader with a special interest in the utilization of non-woody fibrous raw materials. The discussion deals adequately with straw, bagasse, and esparto, but gives little attention to bamboo, a raw material that is becoming of increasing importance in tropical and sub-tropical areas, and only passing mention to other non-woody raw materials.

The value of this book to the American

reader is diminished somewhat by the British viewpoint of the author. While some reference is made to conditions and problems in countries other than Great Britain, the author seems to draw most heavily on his familiarity with problems and experiences of the British cellulose industries. For example, the manufacture of hardboard and other fiberboards is given only brief mention pertaining primarily to experimental manufacture of hardboard from tropical timber wastes. The lack of information on manufacture of fiberboards possibly results from the fact that the United Kingdom produces only a relatively small amount of these products. In contrast, the book includes a rather complete discussion of the utilization of esparto, a raw material which on the world scene is only of minor importance.

"Cellulose Pulp and Allied Products" will appeal primarily to the reader with a general interest who wishes to gain a familiarity with the manufacture and utilization of cellulose pulp. For those who wish to explore beyond the limits of this work, a bibliography is included with each chapter. These bibliographies however, would be much more useful if titles were included with the references.

The subject of Grant's text is very extensive and is not easily dealt with in a single volume. The author has done well to reduce the most important information in this field to one comprehensive volume, and yet present the material in such a manner that it will appeal to the reader lacking technical knowledge of pulp manufacture. The book is adequately illustrated with 75 photographs and drawings. The drawings are in general very simple and are well-selected to illustrate specific features to the reader who is not familiar with processes and equipment used in the manufacture of cellulose pulp.

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*New Crops Research Branch*
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